EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING

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Dr. Vikramjeet Singh

LIST OF ABBREVIATIONS

- **ANOVA** - Analysis of Variance
- **AO/OTA**- Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
- **ATLS** - Advanced Trauma Life Support
- **CT** - Computed Tomography
- **DR** - Digital Radiography
- **EAOJ** - East African Orthopaedic Journal
- **FDA** - Food and Drug Administration
- **FSF** - Femoral Shaft Fractures
- **HIP** - Hip International Pain
- **IMN** - Intramedullary Nailing
- **KLS** - Knee Lysholm Score
- **MRI** - Magnetic Resonance Imaging
- **mRUSF** - Modified Radiological Union Scale for Femur
- **MVC** - Motor Vehicle Collisions
- **NHS** - Nonarthritic Hip Score
- **RSA** - Road side Accidents
- **RTA** - Road Traffic Accidents
- **RUSF** - Radiographic Union Score of the Femur
- **AFN**- Antegrade Femur Nail
- **RFN-** Retrograde Femur Nail
- **DFN-** Distal Femur Nail
- **SD** - Standard Deviation
- **SS** - Stainless Steel
- **VAS** - Visual Analogue Scale
- **mHHS** - Modified Harris Hip Score
- **OKS** - Oxford Knee Score

ABSTRACT

Background and aim: Femoral shaft fractures with third fragments (AO/OTA 32-B/C) comprise 10–34% of all femoral shaft fractures. Closed Intramedullary interlocking nailing is the gold standard technique used for the treatment of such fractures. This study aims to determine whether the displacement and size of third fragment affect the union rate, union time and clinical outcomes in these fractures treated with closed reduction and internal fixation with an intramedullary interlocking nailing (both antegrade and retrograde).

Material and methods: This study included 106 patients with average age 32.3 years (range 18-60 years), treated from 1st September 2020 to 30th September 2023 including a prospective study period from 1st March 2022 to 30th September 2023 (n=71) and a retrospective study period from 1st September 2020 to 28th February 2022 (n=35). The study included patients with AO/OTA type 32B and 32C closed femoral shaft fractures treated with closed intramedullary interlocking nailing. Type 32A fractures, fractures requiring open reduction, fractures associated with ipsilateral femur neck fractures, fractures presenting after >3 weeks, and pathological fractures were excluded from study. Fractures were assessed for third fragment characteristics using Lee et al.'s criteria for fragment length (Group A: 0–3.9 cm, Group B: 4–7.9 cm, Group C: ≥8 cm) and displacement (P1/D1: 0–9 mm, P2/D2: 10–19 mm, P3/D3: 20–29 mm, P4/D4: ≥30 mm). Lin et al.'s criteria classified fragment displacement into two groups: Small Gap (<10 mm) and Large Gap (≥10 mm). Patients underwent monthly follow-ups for clinical and radiological evaluation of union rate and time. Functional outcomes were assessed using the Modified Harris Hip Score, Oxford Knee Score, and VAS score. The study compared functional outcomes between antegrade and retrograde nailing techniques.

Results: 21-30 years was the most common age group (38.7%) with male being involved in 84.9% of all fractures. Roadside accident was the dominant cause (94.3%). Right side was involved in more than 2/3rd of fractures (68.9%). This study observed an overall union rate 89.6% with no significant difference in union rates in group A, B&C (p=0.129). However, larger fragments (≥8 cm) were associated with significantly longer union times (p = 0.04). Fragment displacement gaps >10 mm did not affect union rates but resulted in extended union times (17.60 vs. 15.68 weeks, p = 0.01). Both AFN and DFN implants demonstrated comparable functional outcomes with no statistical difference in Hip and Knee scores.

Conclusion: There was no significant difference in union rates among fractures with different fragment size; however, increased fragment displacement was associated with longer union times. Thus routine fracture site opening for encerclage or manipulation is not recommended. In cases with large fragments or significant displacement, delayed union can be expected, necessitating careful monitoring and postponed weight-bearing to optimize outcomes.

Keywords: Non-union, Third Fragment, Fracture shaft femur, Intramedullary nailing, Functional outcome

TABLE OF CONTENTS

S. NO.	TOPIC	PAGES
I	INTRODUCTION	1-4
II	AIMS AND OBJECTIVES	5
III	REVIEW OF LITERATURE	6-27
IV	MATERIALS AND METHODS	28-37
V	OBSERVATIONS AND RESULTS	38-77
VI	DISCUSSION	78-90
VII	SUMMARY AND CONCLUSIONS	91-93
VIII	BIBLIOGRAPHY	94-99
	APPENDICES – I - PROFORMA - MASTER CHART	
	APPENDICES – II - APPROVAL LETTER OF THESIS PLAN - THESIS PLAN	

LIST OF TABLES

Table No.	Title	Page No.
1.	Scoring used for Modified Harris Hip score	35
2.	Scoring used for Oxford Knee Score	36
3.	Distribution of patients with third fragment according to AGE	39
4.	Distribution of patients with third fragment fracture according to gender	40
5.	Distribution of patients with third fragment according to clinical History	41
6.	Distribution of patients with third fragment according to side affected	42
7.	Distribution of patients with third fragment according to site of fracture	43
8.	Distribution of patients according to implant used	44
9.	Distribution of patients with third fragment according to AO/OTA Fracture Class	45
10.	Comparison of fracture union rate and fracture type (32B and 32C AO/OTA)	46
11.	Comparison of union time with respect to fracture type (32B and 32C AO/OTA)	47
12.	Association of fracture union rate and fracture subtypes (32B2 and 32B3 AO/OTA)	48
13.	Comparison of fracture union time and fracture subtype (32B2 and 32B3)	49
14.	Association of fracture union rate and fracture subtype (32C2 and 32C3)	50
15.	Comparison of fracture union time and fracture subtype (32C2 and 32C3)	51
16.	Association of fracture union rate and Segment of fracture	52
17.	Comparison of fracture union time and segment of fracture	53
18.	Distribution of the patient groups with respect to fragment size according to axis length	54

19.	Association of Fragment size according to axis length with fragment Displacement proximally	55
20.	Comparison of Fragment size according to axis length with Mean Proximal displacement	56
21.	Association of Fragment size according to axis length with fragment Displacement distally	57
22.	Comparison of Fragment size according to axis length with Mean distal displacement of fragment	59
23.	Comparison of fracture union rate with Fragment size according to axis length	60
24.	Comparison of fracture union time with Fragment size according to axis length	61
25.	Distribution of the patient groups with small and large gap (LIN MEHOD)	62
26.	Grouped data comparison of displacement by Lin method with third fragment size	63
27	Comparison of union rate among patients according to fragment displacement (Lin method)	64
28	Comparison of union time among patients categorized by Fragment displacement by the Lin method	65
29	Comparison of fracture union rate according to Fragment's proximal displacement	66
30	Comparison of fracture union time according to Fragment's proximal displacement	67
31	Comparison of fracture union rate according to Fragment's Distal displacement	68
32	Comparison of fracture union time according to Fragment's Distal displacement	69
33	Association of knee function using Oxford knee score and type of implant used	70
34	Association of Hip function using Modified Harris Hip score and type of implant used	72
35	Distribution of patients according to Functional Outcomes at	73

	final follow up	
36	Distribution of patients according to complications	75
37	Distribution of different procedures performed for complications	76

LIST OF FIGURES

Fig. No.	Title	Page No.
1	Anterior view of femoral shaft	7
2	Posterior view of femoral shaft	8
3	Schematic diagram of arterial supply of femoral shaft	9
4	Muscular attachments and fracture location determine the observed deformities and displacements	11
5	mechanism for butterfly fracture formation	12
6	Winquist and Hansen classification	14
7	AO classification for diaphyseal segment shaft femur	14
8	Patient position and Draping	30
9	Making of entry point	30
10	Proximal reaming	30
11	Inserting guide wire	30
12	Sequential Reaming	31
13	Reaming under C-ARM	31
14	Nail Insertion	31
15	Nail Insertion under C-ARM	31
16	Proximal locking	31
17	Distal Locking (Free hand technique)	31
18	Fragment length	34
19	Fragment displacement	34
20	Visual Analog Scale (VAS)	37
21	Consort diagram of patients selection for study	38
22	Distribution of patients with third fragment according to AGE	39
23	Distribution of patients with third fragment according to gender	40
24	Distribution of patients with third fragment fracture according to clinical History	41
25	Distribution of patients with third fragment fracture according to side	42

	affected	
26	Distribution of patients with third fragment according to site of fracture	43
27	Distribution of patients according to implant used	44
28	Distribution of patients with third fragment fracture according to AO/OTA Fracture Class	45
29	Comparison of fracture union rate and fracture type (32B and 32C AO/OTA)	46
30	Comparison of union time with respect to fracture type (32B and 32C AO/OTA)	47
31	Association of fracture union rate and fracture subtype (32B2 and 32B3)	48
32	Comparison of fracture union time and fracture subtype (32B2 and 32B3)	49
33	Association of fracture union rate and fracture subtype (32C2 and 32C3)	50
34	Comparison of fracture union time and fracture type (32C2 and 32C3)	51
35	Association of fracture union rate and Segment of fracture	52
36	Comparison of fracture union time and segment of fracture	53
37	Distribution of the patient groups with respect to fragment size according to axis length	54
38	Association of Fragment size according to axis length with fragment Displacement proximal	55
39	Comparison of Fragment size according to axis length with Mean proximal displacement	56
40	Association of Fragment size according to axis length with fragment Displacement distally	58
41	Comparison of Fragment size according to axis length with Mean distal displacement of fragment.	59
42	Comparison of fracture union rate with Fragment size according to axis length	60
43	Comparison of union time with Fragment size according to axis	61

	length	
44	Distribution of the patients groups with small and large gap (LIN MEHOD)	62
45	Grouped data comparison of displacement by Lin method with third fragment size	63
46	Comparison of union rate among patients according to fragment displacement (Lin method)	64
47	Comparison of union time among gaps categorized by Fragment displacement by the Lin method	65
48	Comparison of fracture union rate according to Fragment's proximal displacement	66
49	Comparison of fracture union time according to Fragment's proximal displacement	67
50	Comparison of fracture union rate according to Fragment's Distal displacement	68
51	Comparison of fracture union time according to Fragment's Distal displacement	69
52	Association of knee function using Oxford knee score and type of implant used	71
53	Association of Hip function using Modified Harris Hip score and type of implant used	72
54	Distribution of patients according to Functional Outcomes at final follow up	74
55	Distribution of patients according to complication rate	75
56	Distribution of different procedures performed for complications	77

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INTRODUCTION

Femoral shaft fractures are prevalent among both paediatric and adult populations, with an incidence rate of 37.1 per 100,000 person-years.[1] Although high-energy trauma, such as motor vehicle collisions, pedestrian accidents, sports injuries, and falls from heights, is the most common cause of this type of injury, low-energy trauma can also result in it, particularly in older individuals with osteoporotic bone.

Femoral shaft fractures often coincide with additional medical conditions, which requires a comprehensive evaluation of comorbidities and the implementation of interdisciplinary treatment. Treatment is determined in consideration of the patient's age, fracture pattern, trauma type, and concurrent injuries.[2]

In the past, treatment options included immobilisation with external splints, skeletal traction, cutaneous traction, and cast bracing. Surgical intervention for femoral shaft fractures results in prompt mobilisation and is presently the prevailing course of action.[2] Intramedullary nailing is the gold standard among the numerous treatment modalities, producing impressive results. It is recommended to perform intramedullary nailing of the femur due to its favourable union rate when biomechanical conditions remain stable. Presently, closed reduction and internal fixation utilising an interlocking nail is widely acknowledged as the conventional approach for managing femoral shaft fractures. This technique has been expanded to encompass nearly all shaft fractures ranging from the proximal to the distal femur.[3] The objective of fixation is sustained functional recovery and early healing.

Femoral shaft fractures were effectively treated and popularised via intramedullary nailing, which Gerhard Kuntscher pioneered. In 1940, he delivered a paper to the Germany Surgical Society titled "Medullary Nailing of Fractures" wherein he described the effective application of a

flexible, compressible, non-ionizing stainless steel by employing the nailing technique previously utilised to secure femoral neck fractures. Subsequently, intramedullary nailing became prevalent. Fractures that are even more severely comminuted may be stabilised through the application of the locking technique. The development of nail designs has enabled the treatment of distal and proximal fractures.[4]

An intramedullary nail can be inserted using either an open or closed technique. Open intramedullary nailing requires the fracture site to be opened in order to acquire reduction and nail insertion into the medullary cavity. The closed technique prevents exposure of the fracture site by approaching it retrogradely or antegradely, contingent upon the initial position of the nail insertion. Femoral shaft fractures are approached via the greater trochanter during antegrade intramedullary nailing; reaming of the medullary canal may or may not be conducted. A trendelberg gait, difficulty initiating the procedure, and pain following union of the implant were identified as adverse effects.[5] In cases of obesity, pregnancy, multiple other fractures, or ipsilateral tibial shaft fractures, retrograde intramedullary nailing is indicated.[6]

A safe location anterior to the insertion of the posterior cruciate ligament and medial to the intercondylar fissure constitutes the optimal portal of entry. Intramedullary nailing facilitates sustained osteosynthesis by means of the nail's flexible penetration into the bone. Additional benefits of intramedullary nailing include a reduced incidence of malunion and limb amputation, enhanced functionality, a decreased length of hospitalisation, and an earlier resumption of work. Significant drawbacks associated with intramedullary nailing encompass rotatory malalignment subsequent to closed nailing, the requirement for a highly advanced operating room equipped with a radiographic unit, and concerns regarding thromboembolic events subsequent to reaming of the medullary canal.

Indications for closed reduction and internal fixation of the shaft femur include a variety of incapacitating and traumatic conditions. Femur fracture operations are among the most frequently conducted surgical procedures in the field of orthopaedics. Proper fixation of femur fractures necessitates the use of closed approaches. Surgical intervention principles include a comprehensive understanding of the region's anatomy and its variations, correct patient positioning, and sufficient reduction. By utilising natural cleavage planes, dissections can effectively reduce haemorrhage and preserve critical functional structures.

Femoral shaft fractures are observed in a range of 10.5% to 34% of all femoral fractures. In the case of a substantial butterfly fragment, anatomical restoration may be complicated to the extent that the residual breach persists even after closed reduction. Managing the third fragment following closed IMN presents a dilemma: should it remain undisturbed, should the fracture site be opened and the fragment be secured with SS-wire or a unicortical plate. However, it is understood that exposing the fracture site may result in complications such as blood loss, infection, and an extended surgical duration, among others.[7]

It is unknown whether a residual gap following closed reduction increases the risk of non-union in such a cohort. In addition, the butterfly fragment may exhibit a morphological reversal in which the endosteum turns inside out. The potential consequences of the reversed fragment on bone regeneration include potential disruption to the vascular bed and challenges in callus bridging across fragment gaps. This kind of Injury is therefore worthy of investigation.[8]

Femoral shaft fractures involving third fragments comprise 10–34% of all femoral shaft fractures, as classified by the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA 32-B/C) fracture type.[9]This injury pattern exhibits a potentially 14% non-

union rate[10]Due to the fact that the anatomical reduction of the fracture is complicated by the presence of a third fragment, bone repair is impeded.[11]Non-union, as defined by the Food and Drug Administration (FDA), pertains to a fractured bone that fails to exhibit complete healing within nine months of the initial injury and has not demonstrated any discernible healing progression on serial radiographs for three consecutive months.[12]

The available literature is not clear with regards to whether to leave these fragments as such or bring these close to the femur shaft or fix them with cerclage. My study aim to determine the parameters whether the displacement and morphology of a fragment in femur fracture Orthopaedic Trauma Association/32- B/32-C (AO/OTA/32-B/32-C) classification affect the outcomes following closed reduction and internal fixation with an interlocking nail which determine union of third fragment.

AIM AND OBJECTIVE

AIM

To determine the effect of the third fragment on the union of femoral shaft fractures managed with closed reduction and internal fixation using closed intramedullary interlocking (Antegrade and Retrograde) nail. This study is planned to include atleast 100 patients aged between 18-60 years with closed 32B and 32C fracture shaft femur with third fragment treated at Dayanand Medical College and Hospital from 1st September 2020 to 30th September 2023 (prospectively from 1st March 2022 to 30th September 2023 and retrospectively from 1st September 2020 to 28th February 2022). Type 32A fractures, fractures requiring open reduction, associated with femur neck fractures, those presenting after > 3 weeks, and pathological fractures were excluded from the study.

OBJECTIVES

- To evaluate the union rates and union time of closed fracture shaft femur with third fragment managed by closed intramedullary (antegrade and retrograde) interlocking nailing.
- To study Hip and Knee function in these patients using Modified Harris hip score and Oxford knee score. Further, Hip and Knee score outcomes between antegrade and retrograde nailing groups were compared for statistical significance.
- To study reoperation rates in fracture shaft femur with third fragment managed by closed intramedullary interlocking nailing.

REVIEW OF LITERATURE

Femoral shaft fractures are among the most frequently treated conditions by orthopaedic surgeons. These fractures are potentially fatal and are frequently associated with polytrauma. They frequently arise as a consequence of high-energy events like motor vehicle collisions (MVCs), leading to deformities and amputations of the affected limbs if not appropriately managed. Femoral shaft fractures (FSF) generally manifest as a bimodal distribution, with younger individuals experiencing high-energy trauma and older individuals enduring lower-energy trauma. FSFs are additionally correlated with comorbidities that require a comprehensive evaluation of advanced trauma life support (ATLS) and interdisciplinary treatment. The prevailing therapeutic approach for patients who are physiologically stable is intramedullary nailing (IMN). The objective of fixation is sustained functional recovery and early healing. Contemporary femoral shaft fractures are treated with remarkable success.

The femur, the longest and strongest bone in the human body, is approximately one-fourth the length of an individual's height. [13] The growth plates of mature individuals converge at approximately 17 years or older in males, and between 16 and 21 years in females, at which point maturity can be determined. The distance across the lesser trochanter (approximately 5 cm distal to it) and the most proximal portion of the medial femoral condyle (approximately 6 cm proximal to it) is the diaphysis of the femur. [6] Diaphysis of femur was defined by Hedlung and Lindgren as a portion of the femur located 15cm proximal to the knee joint line and 10cm distal to the lesser trochanter. [14]

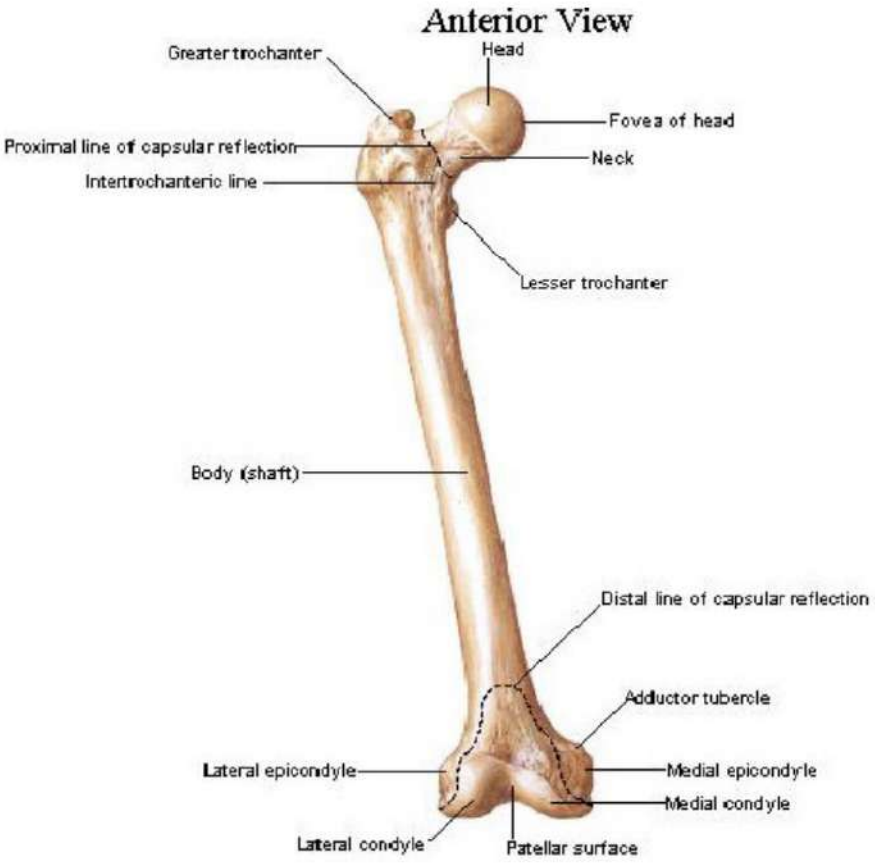

Fig.1 Anterior view of femoral shaft

The femoral shaft possesses an anatomical anterior curve. [15] The degree of curvature is extraordinarily variable. It has a nearly cylindrical shape, is marginally broader distal to its apex, and is slightly more elliptical in shape proximally. The area with the greatest cortical thickness is posterior to the Linea aspera, where the fascia Lata inserts. [16]

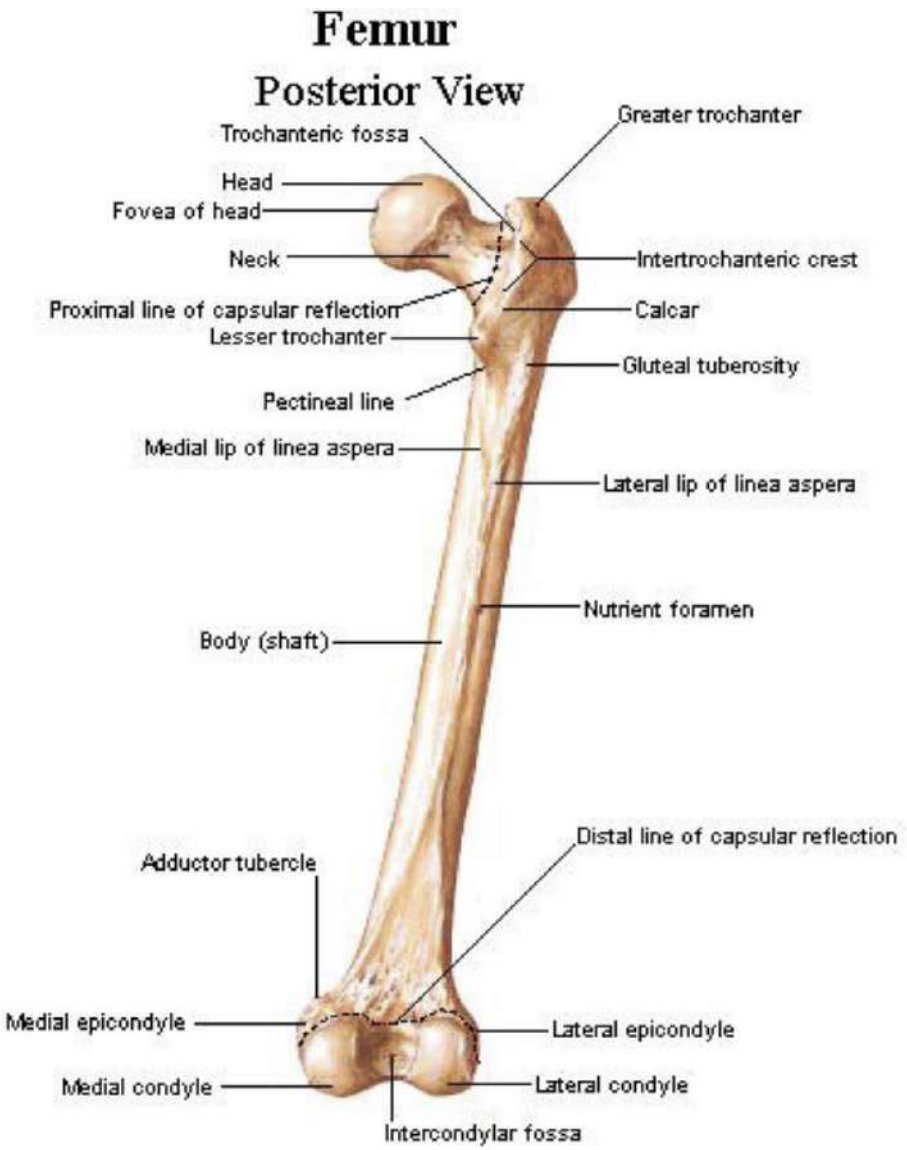

Fig.2 Posterior view of femoral shaft

The medullary cavity exhibits variation in both diameter and morphology. [17] At its narrowest point along the isthmus, its diameter ranges from 8 to 16 millimetres. Slightly proximal to the midshaft is the isthmus. [18]

The principal arterial blood vessel supplying the femur is the nutrient artery, which originates from the profunda femoris artery. [19] Upon entering the femur, the artery supplies endosteal blood. It provides three-quarters to the inner two-thirds of the cortex. Distally, a second artery that provides centrifugal-directional supply may be present. [20]

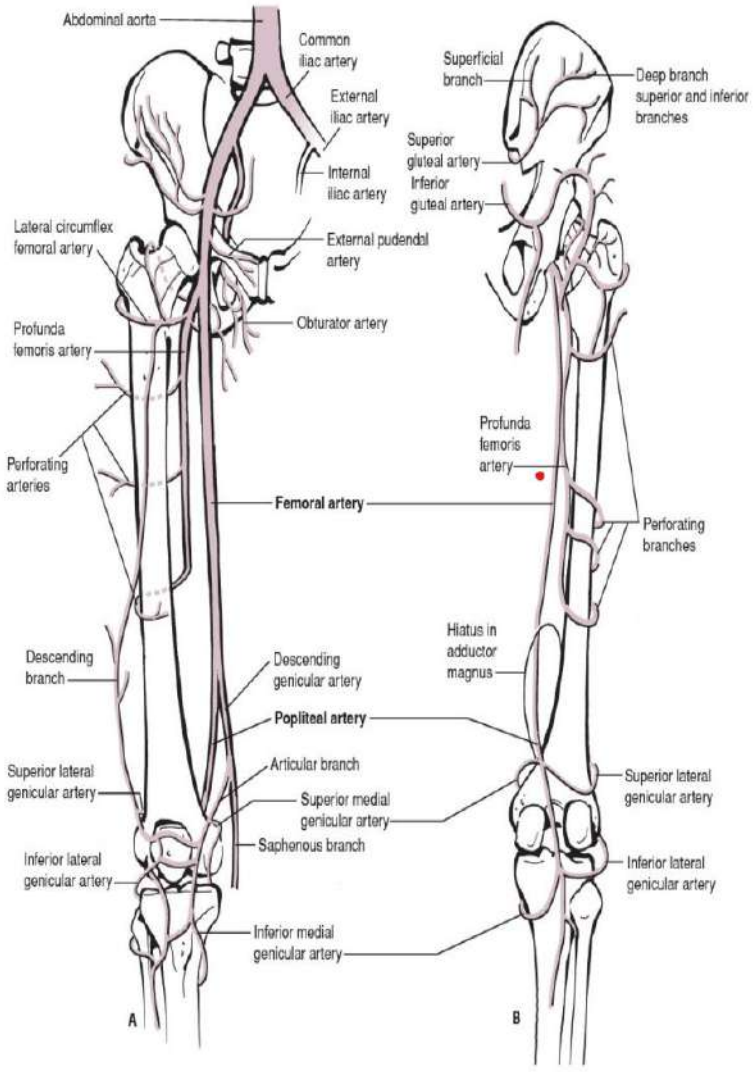

Fig.3 Schematic diagram of arterial supply of femoral shaft

The majority of the periosteal circulation enters posteriorly along the linea aspera. It delivers in a circumferential direction, with minimal or negligible longitudinal dispersion. Small wires may therefore be transmitted around the femur without posing a risk of devascularization. Endosteal and periosteal blood flow are indispensable for fracture healing.

Displaced fractures of the femoral shaft lead to endosteal circulation disruption, with the periosteal vessel serving as the primary vascular supply to the fracture in the initial stages of healing. [21] Consequently, periosteal removal ought to be precluded in the course of fracture fixation. Preserving the muscle envelope surrounding the fracture

promotes periosteal callus formation and enhances revascularization of the injured bone.

Gravity, initial force, and muscular activity all contribute to the displacement of femoral shaft fractures. [22]

The gluteus medius and gluteus minimus, as well as the gemelli, obturator internus, and quadratus femoris, are all involved in the abduction of the proximal fragment in the proximal third. The iliopsoas is responsible for external rotation and flexing. The adductor and hamstring muscles cause the distal fragment to be displaced medially and upward.

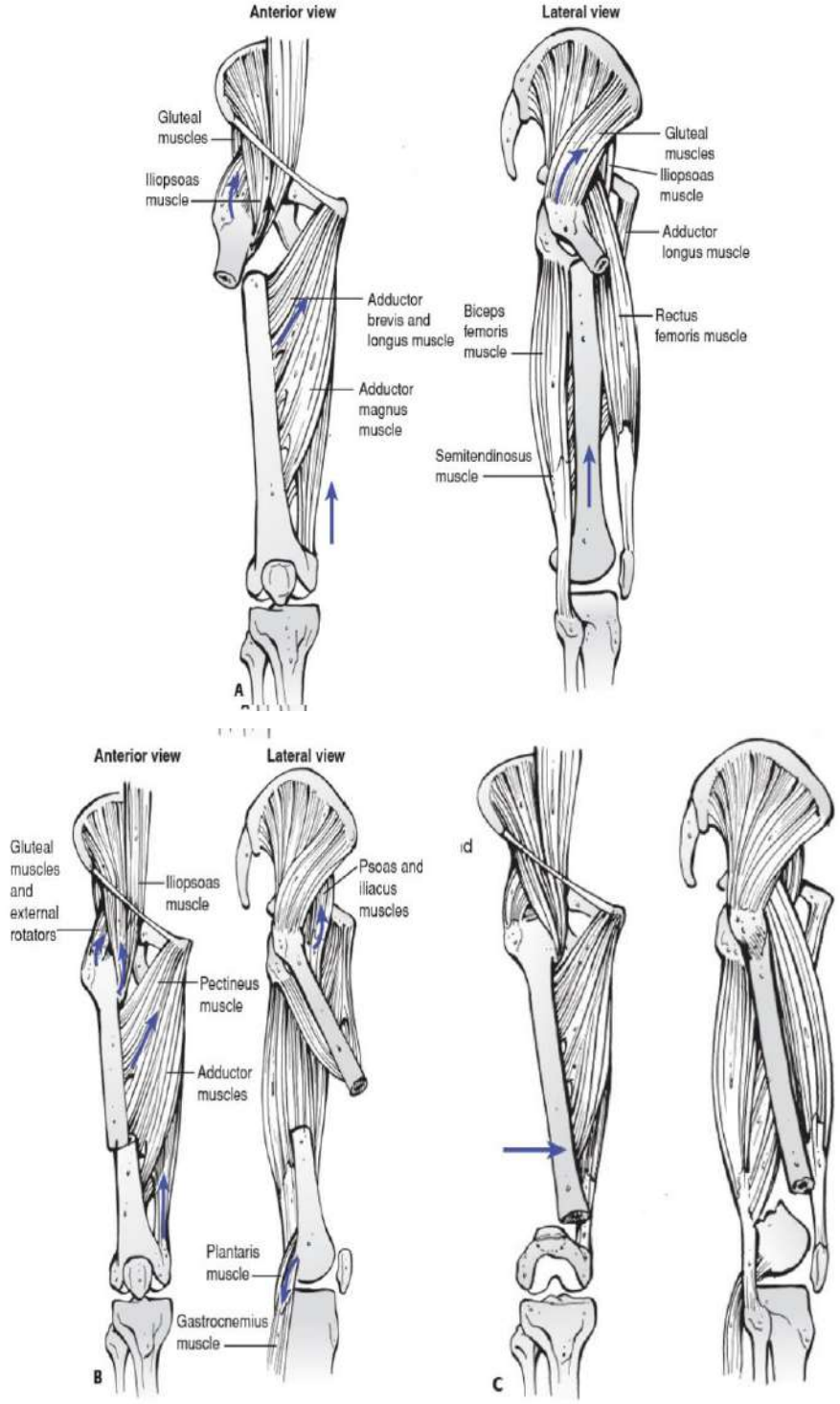

Fig.4 Muscular attachments and fracture location determine the observed deformities and displacements.

In the middle third, the proximal fragment is adducted with strong axial and varus force by the adductor muscles. It is flexed by the iliopsoas muscles. The distal fragment of femur is rotated by the gravity. The adductor and hamstring muscles displace the distal fragment upward

and posteriorly. The iliopsoas and adductor muscles causes flexion, adduction of proximal fragment of the supracondylar fractures of femur. The gastrocnemius causes flexion of the distal fragment posteriorly and can cause injury to the neurovascular structures.

BIOMECHANICS OF FRACTURE

The classically described mechanism for butterfly fractures is a fracture resulting from combined bending and compression forces on the bone. The bending force creates tension at the far side of the neutral axis and compression at the near side of the neutral axis. The fracture begins with a transverse tension fracture on the far cortex. Compression at the near cortex results in failure in shear with typical 45-degree oblique fracture lines. The combination of oblique compressive fracture lines joining with the transverse tension fracture line generates the butterfly fragment. The energy required to form a butterfly fracture is higher than for transverse or simple oblique fractures.

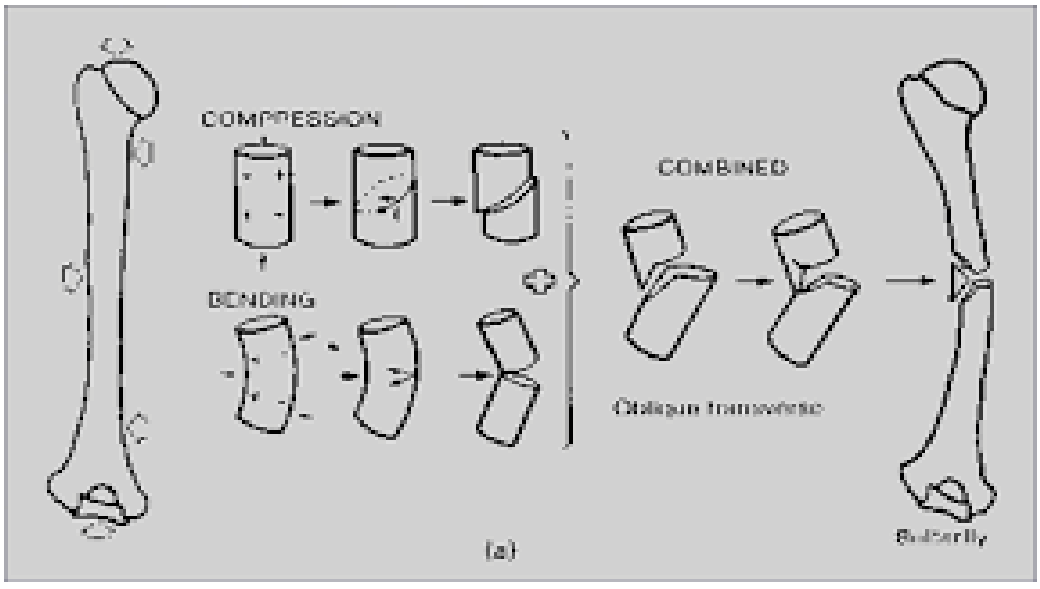

Fig.5 Mechanism of butterfly fragment formation

The bending component of the load results in tension on the cortex on the far side of the neutral axis and compression on the near side from the applied load. Tension causes a transverse fracture line, and

compression results in two oblique fracture lines, generating a butterfly fracture.

Butterfly fractures may also occur after progressive loading of short or long oblique fractures wherein the short or long oblique fragment is sheared by the adjacent bone segment, resulting in a butterfly fragment. In this case, all fracture lines are oblique, without a transverse component.

FRACTURE CLASSIFICATION

CLASSIFICATION OF FEMORAL SHAFT FRACTURES IN ADULTS: Based on the fracture geometry, displacement, alignment, comminution, and whether the fracture is open or closed, femoral shaft fractures can be categorised. Winquist and Hansen classification and AO classification are two frequently used classification schemes apart from Tsherne and Oestern classification of closed fractures. [23]

WINQUIST AND HANSEN CLASSIFICATION: The degree of fracture comminution determines the preferred form of medullary fixation and locking of major fragments of the fracture.

Winquist and Hansen classification

Degree of Comminution Grading

Grade 0: No evidence of comminution.

Grade 1: Presence of a small butterfly fragment or a minimally comminuted segment, with at least 75% of the cortical contact maintained between the diaphyseal segments.

Grade 2: A butterfly fragment or comminuted segment with at least 50% of the cortical contact preserved between the diaphyseal fragments.

Grade 3: A large butterfly fragment or comminuted segment with minimal cortical contact remaining between the diaphyseal fragments.

Grade 4: Complete comminution with no cortical contact predicted between the diaphyseal fragments; segmentally comminuted.

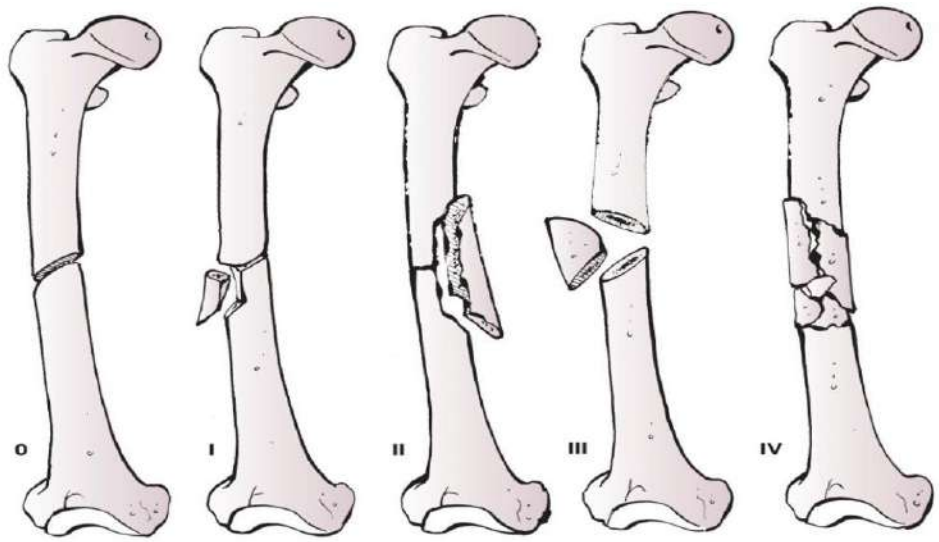

Fig.6: Winquest and Hanson classification

AO CLASSIFICATION:

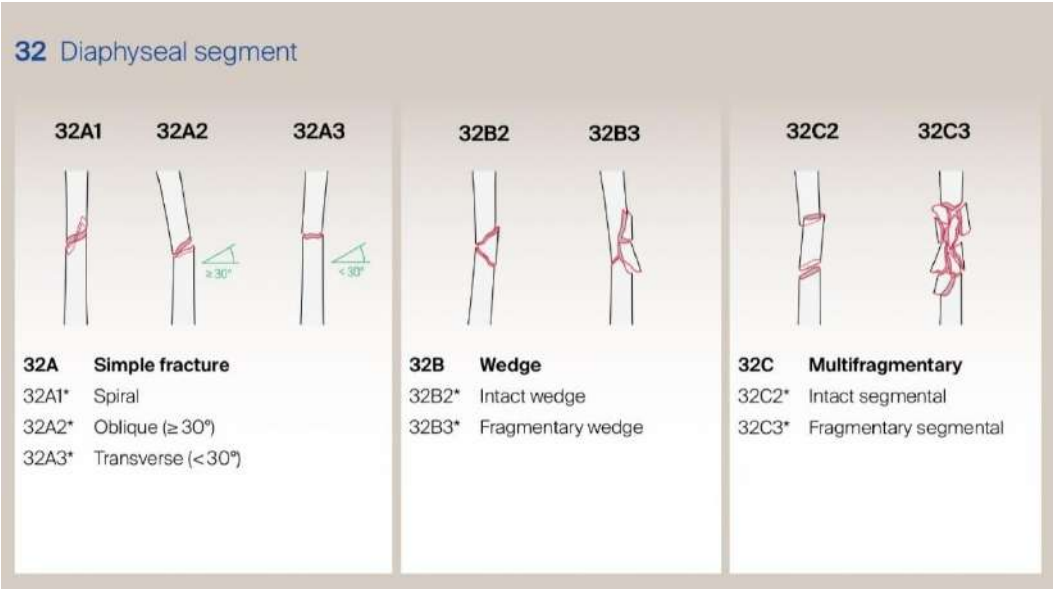

Fig.7: AO Classification for Diaphyseal Segment fracture shaft femur

MECHANISM OF INJURY

All age groups have femoral shaft fractures, which can be caused by a number of different methods. Fractures tend to occur in a bimodal distribution according to age and gender, with young men suffering high-energy trauma and elderly women falling from a standing position

suffering the greatest injuries. Road traffic accidents, which include collisions involving cars, motorcycles, and pedestrians, are the main cause of injuries. According to Demetriades (2005), falling from a height of more than three to four metres could be another mechanism of injury.[24] Low intensity trauma such as sports injuries, falls from less than one metre high, and slipping or stumbling at ground level can result in femoral shaft fractures. Younger people typically suffer fractures from high-energy trauma, stress fractures, and pathological fractures.

DIAGNOSIS

The primary methods for diagnosing these fractures are radiographic examinations and clinical presentation. With the exception of pathological fractures, where the history may not be compatible with trauma, the most common history for fractures is trauma.

Tenderness, oedema, shortening, and deformity at the fracture site are found during a clinical examination. A thorough examination is necessary to assess any hip dislocation, intertrochanteric fracture, and ipsilateral neck of femur fracture. The pelvic ring is examined for any signs of simultaneous pelvic disruption, such as discomfort, oedema, or ecchymosis. The afflicted limb should undergo a neurological evaluation and comparison with the contralateral side. Carefully evaluating hemodynamic stability is an important part of the patient's preoperative evaluation. High velocity vehicle injuries are linked to Waddell's triad of femur fracture, intra-abdominal or intra-thoracic injury, and head injury. When the haematocrit result is less than 30%, multisystem damage should be suspected.

Plain radiograph: Prior to taking radiographs, the extremity must be splinted to prevent further soft tissue damage. To find any fracture or nondisplaced comminution, anteroposterior and lateral views of the

knee, anteroposterior image of the pelvis, and anteroposterior view of the entire femur should be obtained.

Computed Tomography: Spiral and longitudinal fractures can be found with CT scanning. In comparison to traditional radiography, it is less sensitive in identifying fatigue fractures.

Scintigraphic Scan: For fatigue fractures, this is currently the most effective diagnostic method. [25] Its sensitivity is very nearly 100%.

Magnetic Resonance Imaging: When it comes to identifying bone fatigue fractures, this is more precise than scintigraphy. The first three weeks are when it is most accurate.

Angiography: When there is a vascular damage, angiography is advised. Hematoma, haemorrhage, hypotension, pulse or neurological ischemia insufficiency, and an ankle-brachial index of less than 1.63 are typical indicators of vascular injury.

Haematological investigations: Since compartments of the thigh can lose comparatively substantial amounts of blood, haemoglobin levels and haematocrit should be checked.

Microbiology: Whenever an infection is suspected, swabs should be collected for sensitivity testing, microscopy, and culture.

History

Early attempts at internal repair of femoral shaft comminuted fractures resulted in problems such as infection and implant failure. Lane introduced plates and screws in 1905. External fixator was described by Lambotte in 1907. In 1918, Hey Groves carried out a large intramedullary nail fixation. In 1939, Keil's Gerhard Kuntscher introduced intramedullary fixation utilising a V-shaped cross section nail that was constructed based on the same concepts that had previously been applied to femur neck fractures. He invented intramedullary reaming and the cloverleaf cross-sectioned nail in 1950. Advances in instrumentation, modifications to nailing insertion procedures, use of fluoroscopy, and advances in the mechanical qualities and design of

intramedullary nails made it possible to treat more complicated and demanding fractures. The osteosynthesis techniques comprising intramedullary fixation and fixation with screws and plates were first introduced by the AO/ASIF group. The techniques of open and closed nailing, interlocking nail use, unreamed interlocking procedures, and retrograde nail insertion changes all contributed to the advancement of intramedullary nailing.

Intramedullary nailing: Nowadays, closed intramedullary nailing is the accepted gold standard for treating femur shaft fractures. Because intramedullary nailing allows for early joint movement and weight bearing and does not require external fixation or particular postoperative care, it is a suitable treatment for fractures and produces a stable osteosynthesis by flexible nail impingement in the bone. [26]In addition, fewer incidences of malunion and limb shortening, better function, a shorter hospital stay, an earlier return to work, and generally faster fracture healing are all benefits of intramedullary nailing. [27]

Kuntscher principles of intramedullary nailing.

1. Nailing under fluoroscopy without direct exposure of the fracture site in order to prevent infection is one of the Kuntscher principles of intramedullary nailing.
2. Using a strong nail to reduce the stress that comes from weight bearing, joint movement, and muscle contraction that can cause nail bending or breaking.
3. To securely fasten the pieces and prevent the fracture from rotating, use a nail with enough elasticity to contract during insertion and to extend again once in position. It serves to maintain the fixation construct's general stability. [28]

As interlocking techniques developed, almost all femoral shaft fracture patterns—regardless of the degree of comminution—were now eligible for intramedullary nailing. Comparing open and closed intramedullary nailing, closed intramedullary nailing necessitates the use of

specialised equipment and radiography facilities. By using external manipulation and a nail that is introduced through the end of the bone without causing injury to the periosteal vasculature, the risk of fracture is reduced. When closed nailing, the fracture hematoma is left in place, preserving the earlier action of local cellular and humoral substances that are essential to the healing process. A decreased rate of infection and less quadriceps scarring are indicated by the smaller surgical dissection. In an open reduction, the nail is inserted and the fracture site is directly exposed through the surrounding muscles. Fluoroscopy is not needed for this quicker operation. It puts the fracture site at risk for both a higher infection rate and a lower blood supply.

Interlocking of the nail: Interlocking nails are intended to manage severe fracture comminution, bone loss, and open fractures at either the proximal or distal fracture level. Dynamic locking is advised for femoral shaft fractures that are simple. Dynamic stabilisation is achieved by transfixation screws in the proximal hole or the distal hole alone. This could lead to rotational and axial compression instability. In fractures where shortening and malrotation are probable, static locking with screws in the proximal and distal fragment is recommended.

Reamed Vs Unreamed intermedullary nailing: The most effective therapy for nearly all femoral shaft fractures is reammed femoral nailing, albeit there is a risk of complications. This includes a noticeable increase in intramedullary pressures as well as the embolisation of air and bone debris into the veins. As a result, it may result in sudden death, adult respiratory distress syndrome, and fat embolism syndrome. In his 1993 research, Kaartinen advised against reaming while reducing a fracture openly because it widens the medullary canal and raises the porosity of the cortical bone. The medullary circulation is negatively impacted by bone fragments and fat emboli that obstruct the arteries and raise pressure inside the medullary cavity. The process of reaming the canal deposits more particles of bone fragments and

marrow components that may have osteoinductive qualities at the fracture site. A bigger nail improves fracture stability.

Antegrade Vs retrograde nail insertion: It is better to use the pyriform fossa entry portal for antegrade nail insertion. Although it has a high union rate, some patients experience weak hip abduction, hip discomfort, bursal pain, and Trendelenburg gait. Retrograde procedures are recommended for patients with multiple traumas, bilateral injuries, pregnancy, and obesity. Treatment for ipsilateral femoral neck, tibia, acetabular, and pelvic fractures can benefit from it.

Fracture and controversies

The success rates of internal fixing and open reduction are high. However, a variety of traumas, including head and chest trauma, are present in individuals with femoral shaft fractures. When the nail is reammed and inserted into the medullary canal, tiny emboli are showered. It is still unclear exactly what the clinical implications are for patients who have had many traumas, particularly chest injuries, or who already have poor pulmonary function. Concerns are raised when intramedullary nailing is used for head injuries. Possible hypotension during the intraoperative phase could worsen the central nervous system's damage. None of the previous studies however, has quantified how the third fragment features could increase the fracture healing time.

REVIEW OF LITERATURE

1) ki-chan 2012 et al Explored The Destiny of Butterfly Pieces in Comminuted Extremity Shaft Fractures. they saw a progressive improvement in displacement and angulation after receiving treatment with closed interlocking intramedullary nailing. It was discovered that the degree of displacement following the initial reduction matters more than the impact of weight bearing or anatomical position. Larger fracture gaps have the potential to

impede bone healing; still, the primary causes of the gap between a fragment and the femoral shaft are haemorrhage expansion, soft tissue interposition, and muscle pull on the fragment. A bigger butterfly piece typically creates a bigger space. This makes the fracture more unstable because a fracture with a larger butterfly fragment is always the result of more axial compression in addition to bending force. [29]

2) In order to better understand how fragmented displacement and morphology affect the treatment of comminuted femoral shaft fractures with intramedullary nails, Shih-Jie Lin et al. (2013) carried out this retrospective study. At one year following surgery, the percentages of the small and wide gap groups were 75.9% and 21.1%, respectively. For the union cases in these two categories, the mean union time was 7.8 and 13.0 months, respectively. At 12 months postoperatively, the non-reversed and reversed groups had union rates of 30% and 11.1%, respectively. In the non-reversed and reversed groups, the mean RUSF at 12 months was 8.8 and 8.3, respectively. They did discover, nevertheless, that patients who presented with a reversed fragment were more likely to require many reoperations. They came to the conclusion that bone healing was impacted by a fragmented displacement of more than 1 cm in AO/OTA-type 32-B/32-C femoral shaft fractures following nailing. For patients in the large-gap group, an unreduced reverse fragment was associated with a poor prognosis for re-operation. [8]

3) Wang et al 2014 determined that a bigger fracture gap has a greater chance of interfering with bone healing. Haemorrhage expansion, soft tissue interposition, and traction of muscles linked to the fragment are the main causes of the gap that forms between a fragment and the femoral shaft. However, they are easily able to shift places, particularly in the early stages of a

bone fracture's healing process. A bigger butterfly component typically creates a bigger space. This makes the fracture more unstable because a fracture with a larger butterfly fragment is always the result of more axial compression in addition to bending force. A larger fragment can easily be held away from its original anatomic place to generate a larger gap because it may have a higher possibility of developing soft tissue or muscle contraction, haemorrhage growth, or both. [30]

4) In a study conducted by J.R. Lee et al. (2016) on the non-union of femoral shaft fractures treated with intramedullary nailing, it was found that the bone union rate was 86% in groups with small fragments (less than 8 cm) and 71% in groups with large fragments (8 cm or more). For both proximal and distal fragment parts, the union rate was lower, and the average union time was longer in cases with 20 mm or more displacement. Specifically, non-union was more frequent in femoral shaft fractures with fragments 8 cm or longer when there was a proximal displacement of 20 mm or more and a distal displacement of 10 mm or more during the intramedullary nailing technique. The degree of displacement in femoral shaft fractures had a greater influence on the union rate than the size of the third fragment. [31]

5) In 2018, Vicenti et al. conducted a retrospective analysis to determine how the radiological characteristics of the third fragment affected the outcome of type 32-B femur shaft fractures treated with intramedullary nailing. Their regression analysis revealed that the size and mean displacement of the third fragment significantly influenced fracture healing time. They found that for fractures to heal within six months, the size of the third fragment (with a cutoff of 40 mm) was the most critical factor. Additionally, a displacement of the third fragment

exceeding 12 mm hindered, but did not completely halt, the healing process. [32]

6) Cheng T 2018 assessed the clinical results of adult polytraumatized patients undergoing double-plating fixation for femur shaft fractures and thoracic injuries. In this retrospective investigation, 15 polytraumatized individuals with femur shaft fractures were included. After surgery, radiographic results and functional results were evaluated 1, 3, 6, and 12 months later. The mean duration to union for femoral shaft fractures was 9.2 months, and 93% of them resulted in bony union. The Lysholm Knee Score was 87.2 points and the Nonarthritic Hip Score was 89.4 points, on average. The legs with and without injuries had similar ranges of motion at the knee joint. Their results imply that orthogonal double-plating fixation, an alternate method to intramedullary nailing for femoral diaphyseal fractures in patients with severe chest damage, restores lower limb function to normal. [33]

7) Hamahashi et al. (2019) examined retrospectively the risk factors for delayed union and the clinical outcomes of intramedullary nailing for femur shaft fractures with third fragments. Multiple logistic regression revealed that the third fragment's displacement was a risk factor for delayed union. [34]

8) Dabak T 2020 examined the effect of these parameters on union and determine cut-off values that necessitate reduction of fragment. A total of 59 patients with fractured femur shafts were examined, and the impact of fragment size, gap size, and fragment position on union was assessed using third, sixth, and twelve-month charts from the patients' medical records. Due to the Radiographic Union Score of the Femur, the union rate was established. The patients were categorised into groups based on

minor gaps (< 10 mm) or large gaps (>10 mm), reverse fragments (≤50 mm) or non-reverse fragments (≠50 mm). There was no discernible difference between the groups at the 3rd, 6th, and 12th months when comparing the union scores of the groups for gap size and fragment size. Union scores were lower in the reverse group than in the non-reverse group in the third and sixth months. However, at the 12-month mark, there was no statistically significant difference between the two groups. Regarding the different types of intramedullary nails, there was no discernible variation in union rates. After six months, the union score of the reverse group was lower than that of the non-reverse group, but by twelve months, the reverse group's union score had recovered to its previous level. [35]

9) Layon et al. (2020) assessed the union rates of fractures to the femur shaft with flipped intercalary segments. Union rates were assessed using radiographic femur union scores (RUSF). Reversed intercalary segments in femur shaft fractures are uncommon, but they can cause surgical problems. Their study ran counter to earlier studies that connected larger intercalary segments to higher rates of non-unionization. Surgery for flipped intercalary segments might not be any different from that for typical femoral shaft fractures. [36]

10) In 2021, Mao Guoshu studied the impact of the third fragment on the healing process after intramedullary nail fixation for femur shaft fractures. A retrospective analysis was performed on 52 cases at Chinese Medicine Hospital and Wuxi People's Hospital, involving patients aged 16 to 69 years. X-ray films measured the third fragment's length and displacement. Patients were divided into three length-based groups: Group A (1.0-3.9 cm), Group B (4.0-7.9 cm), and Group C (≥ 8 cm), and three displacement-based groups for proximal (P) and distal (D): Group D1/P1 (0-9

mm), Group D2/P2 (10-19 mm), and Group D3/P3 (≥ 20 mm). After 12 months, the overall healing rate was 79%. No significant differences in non-union rates or healing duration were observed based on fragment length. However, healing rates and times varied significantly with proximal and distal displacement. Higher displacement correlated with slower healing and longer healing times. Logistic regression indicated that displacement, not fragment length, substantially impacted healing. When displacement exceeds 1 cm, reduction or fixation of the third fragment is recommended. [37]

11) Jamoh et al. (2021) determined the union rate of broken femur shafts with third pieces after closed intramedullary nailing by conducting a retrospective analysis. There was AO/ASIF categorization. Breaks were treated with intramedullary closed nails, which were monitored in the outpatient department until the fracture healed. The results showed that the union of a shaft femur fracture took an average of thirty weeks, which is longer than usual. After treating shaft femur fractures with third fragments using the closed intramedullary nail approach, they concluded that the union rate of the bone is proportional to the displacement of third fragments and is independent of fragment size. [38]

12) Tsai et al (2022) compared intramedullary (IM) nailing with and without third piece fixation. There were two treatment groups: open reduction with fixation and closed reduction with no impact on the third fragment. They came to the conclusion that in wedge-shaped femoral shaft fractures, fixing the third piece slows healing and lowers union rates. It is recommended to use closed fixation and a larger nail size when treating a femur fracture with a third fragment. Fragment fixing enhances the

decrease of fractures. Non-union may result from disruption of the surrounding structures and the vasculature. [39]

13) In 2022, Yang et al. examined how the degree of displacement of the third fragment affects fracture healing after intramedullary nailing. They found that minor displacement of the third fragment required no intervention. However, fractures with significant displacement should be reduced as close to the diaphyseal bone defect as possible to prevent non-union. When displacement can be limited to the grade I range, closed reduction treatment of the third fragments is recommended to reduce the incidence of non-union.[40]

14) The results of femur fracture procedures using nondisplaced and displaced butterfly fragments were compared by Alrasheed O (2022) six months after surgery. Metrics included the healing progress, presence or absence of cortical abnormalities, pain score at six months, and need for revision surgery. This study examines 100 individuals who underwent intramedullary nail treatment for butterfly femur fractures. The patients were split into two groups: 48 patients who had surgically displaced butterfly fragments, and 52 patients in the second group who had nondisplaced butterfly fragments. None of the patients' butterfly fragments were fixed in any way, and none of them were approximated using closed or open reduction techniques. Of the first group, 62.5% had a cortical defect, 12.5% needed revision surgery, 79.2% showed delayed union six months after surgery, and 87.5% were still experiencing pain. In the second group, 19.2% reported discomfort six months after surgery, 15.4% displayed delayed union, none had cortical abnormalities, and 07.7% needed revision surgery. Reduced to near-anatomical alignment, displaced butterfly fragments should avoid delayed union, cortical abnormalities, and discomfort. [41]

15) Salvatore Bonfiglio 2023 evaluated the potential effects of third fragment on fracture healing, including the surgical technique used and fragment size, angulation, displacement degree, and reverse fragment. The authors analyse two instances with different approaches with the third fragment treated with both an open and close reduction method. The inclusion criteria were met by 70 patients in total who had a mean follow-up of 16.9 months and a third fragment. Patients were categorised into four groups (1A, 1B, 2A, and 2B) based on the surgical method, third fragment displacement, and dimension. The fractures with fragments less than 5 cm and displacements less than 1 cm showed the best fracture healing, while the fractures with fragments longer than 5 cm and displacements greater than 2 cm and/or reverse fragments showed the worst fracture healing. The patients in Group 2 who underwent an open reduction method had the best results. And also they put out a novel algorithm based on the features of femoral shaft fractures involving a third component. [42]

16) Cho, WT 2024 evaluated the radiographic results and risk variables related to non-union in fragmented segmental fractures of the femur shaft that were treated with reamed antegrade intramedullary nailing. Evaluations were conducted on radiological outcomes, such as alignment and union. The number of interlocking screws, segmentation length, main third fragment length, distance of the main third fragment, width ratio, and exposed nail length in one cortex from immediate post-operative radiographs were among the treatment-related characteristics and demographics that were examined as risk factors for non-union. 51 femoral shaft fractures out of 2295 satisfied the inclusion requirements. 73% of cases resulted in radiological union, with a mean union time of 10.7 +/- 4.8 months. In 59% of cases, the proper axial alignment was noted. Only exposed nail length was found to be a significant risk factor

for non-union by multiple logistic regression analysis; 19.1 mm was the cut-off value. High incidences of malalignment (41%) and non-union (27%) were found in the study. As a result, patients who had intramedullary nailing and had exposed nail lengths longer than 19.1 mm, or roughly double the diameter of the nail, should be advised that non-union may occur. [43]

MATERIAL AND METHODS

Study Duration: 1st September 2020 till 30th September 2023.

This study was conducted in the Department of Orthopaedics, Dayanand Medical College and Hospital, Ludhiana, from 1st September 2020 to 30th September 2023 (prospectively from 1st March 2022 to 30th September 2023 and retrospectively from 1st September 2020 to 28th February 2022). Based on previous years' data, the study planned to include at least 100 patients with closed femur shaft fractures with a third fragment, classified under AO/OTA types 32B and 32C, managed surgically with intramedullary interlocking nail (both Antegrade and Retrograde).

Number of thesis cases:

The study included 106 patients with closed femur shaft fractures with a third fragment which met the inclusion and exclusion criteria. In the prospective period, 71 patients met the study criteria and were included. In the retrospective study period, 35 patients also met the study criteria and were treated with the same protocols as the prospective group, so these patients were also included thus making a total of 106 patients.

The **two groups** (1st March 2022 to 30th September 2023 and from 1st September 2020 to 28th February 2022) represent the prospective and retrospective intake of cases which was done to complete the sample size as per thesis plan. These two groups were treated and followed up using the same protocols, so these have been studied together as a single group for data analysis.

METHODS OF COLLECTION OF DATA

INCLUSION CRITERIA

- Patients in the 18-60 years age group, either gender.
- Closed femur shaft fracture type 32-B and 32C (AO/OTA) surgically managed with intramedullary nailing (retrograde/anterograde).
- Patients who consented to the surgery.
- Minimum clinical and radiological follow-up of at least 6 months.

EXCLUSION CRITERIA

- Type 32-A fractures according to the AO/OTA classification system.
- Surgical management with open reduction and internal fixation.
- Concomitant ipsilateral femur neck fracture, periprosthetic fracture, or open fractures.
- Duration of fracture >3 weeks.
- Patients with pathological fractures or previous surgeries of the involved femur.

Data Collection and Analysis:

Data was collected as per the standard proforma after obtaining consent from the patients. A detailed history was taken from all the patients with femur shaft fractures. Demographic information such as age, sex, mode of injury, and fracture characteristics was recorded. X-rays were obtained using AGFA DR400 and AGFA DR800 systems, and measurements were performed with WORKSTATION NX.3.0.9000SU1. A femoral shaft fracture was defined as a fracture in the area beginning 5 cm distal to the lesser trochanter and ranging to 5 cm proximal to the adductor tubercle. Patients were followed up for union or six months, whichever was later.

Surgical technique: All femur fractures were fixed by the standard method of antegrade and retrograde femoral nailing.

Patient positioning and preparation

Antegrade nail (AFN):-

The patient was kept supine on a radiolucent table with affected limb paint and draped. Traction was applied to the affected leg, and length is achieved as confirmed under fluoroscopy. The rotation and position of fragments were understood before giving incision under the fluoroscope.

Operative Technique

The greater trochanter is palpated, and a 3 cm incision was given 3 cm proximal to the greater trochanter along the femoral axis. The entry point was made with an awl over tip of the greater trochanter. The entry point was wide opened with with a cannulated proximal reamer. A guidewire was passed across the fracture fragments with fluoroscope guidance up to the distal femur epiphyseal line. Sequential Reaming of the medullary canal was done with a cannulated reamer with raise of 0.5mm during each reaming. The nail size selected was 1.5mm less than maximum reamer width which was used. Femoral nail (titanium) was fixed with jig and inserted over the guide wire under fluoroscope for proper positioning. Distal locking was done by freehand technique under c-arm guidance. Proximal locking was done through a jig. The wound was closed in layers, and a sterile dressing was applied.

Fig.8: Patient position and Draping

Fig.9: Making of entry point

Fig.10: Proximal reaming

Fig.11: Inserting guide wire

Fig.12: Sequential Reaming

Fig.13: Reaming under C-ARM

Fig.14: Nail Insertion

Fig.15: Nail Insertion under C-ARM

Fig.16: Proximal locking

Fig.17: Distal Locking (Free hand technique)

Retrograde nail/ DFN (Distal femur nail): -

The patient was kept supine on a radiolucent table with affected limb paint and draped. The thigh was supported with sheets to flex the knee joint 20-30 degrees. Traction was applied to the affected leg, and length is achieved as confirmed by the fluoroscopy. The rotation and position of fragments were understood before giving incision under the fluoroscope.

Operative Technique

Incision given in infrapatellar region, from inferior pole of patella to tibial tuberosity. Patellar tendon incised and intercondylar notch felt with guide wire. Guide wire inserted in middle of intercondylar notch in AP view, in lateral view, just above blumansaat's line in lateral view under C-ARM guidance. The entry point widened with proximal reamer. Guide wire inserted along the femur axis and fracture site crossed under C-ARM guidance. Sequential reaming was done with cannulated reamers post reduction of fragments and reamer size was raised by 0.5mm during each reaming. The nail size selected was 1.5mm less than maximum reamer width which was used. Femoral nail (titanium) was fixed with jig and inserted over the guide wire under fluoroscope for proper positioning. Distal locking was done through a jig. Proximal locking was done by freehand technique under c-arm guidance. The wound was closed in layers, and a sterile dressing was applied

Postoperative Protocol

Dose of postoperative antibiotics was given with adequate pain control medications. Static and dynamic quadriceps exercises were started after 24 hours. Early knee mobilization was encouraged after 48 hours as far as the patient tolerates pain. Non-weight-bearing walking with a walker was advised as soon as possible. Suture removal was routinely done on the 14th day. Partial weight-bearing was advised after four weeks. Full weight-bearing was advised after 12 weeks. All patients were followed up monthly, upon which clinical, and radiographic evaluation was done to assess the fracture healing.

Post-operative Method of Assessment: Assessment was done using criteria used by Lee et al. and Lin et al.

Lee et al. [31] **used two parameters:**

1. Fragment length:
    - The size of each fracture fragment was determined by measuring the length of its long axis using plain radiographic images.
    - Fragments were divided into the following groups according to axis length:
        - Group A (0–3.9 cm)
        - Group B (4–7.9 cm)
        - Group C (8 or >8 cm)
2. Fragment displacement:
    - This was measured by determining the perpendicular distance of the proximal (P) or distal (D) end of the third fragment to the nearest cortex of the femoral shaft. The longest perpendicular distances between the P tips and the D tips of the fragments was measured.
    - Fractures were then divided into the following groups based on the above criteria:
        - Group P1 or D1 (between 0–9 mm)
        - Group P2 or D2 (between 10–19 mm)
        - Group P3 or D3 (between 20–29 mm)
        - Group P4 or D4 (30 mm or more).

Lin et al. [8] **used one parameter:**

1. Displacement of the third fragment:
    - The enrolled patients with femoral shaft fractures were subdivided into two groups based on Lin’s criteria:

- Small gap (<10 mm)
- Large gap (10 or >10 mm)

- The formula used to calculate the numerical value for classifying the displacement of third fragment into small gap and large gap groups was $D_{prox} + D_{dist} - B_d$, where

  D_{prox}/D_{dist} represent the largest perpendicular distances of the proximal/distal ends of the fragments to the midline of the shaft, as measured from anteroposterior and lateral radiographs. B_d is the diameter of the shaft at the fracture site on the same radiographs.

Fig.18: Fragment length **Fig.19: Fragment displacement**

Postoperative Management:

- Range of motion was initiated postoperatively after 24 hours of surgery. Weight-bearing walking was initiated according to fracture geometry and fixation construction. Weight bearing was increased according to the progress of fracture union.
- Follow-up was on a monthly basis for clinical and radiological signs of union. Weight-bearing walking was decided according to the progress of bone union.

- Bone union was defined as bone continuity in 3 or more of the 4 cortical bone surfaces. Radiographic bone union rates and times according to fracture size and degree of fragment displacement were investigated.

FOLLOWING OUTCOMES WERE MEASURED:

- **Union status:** The "union status" referred to whether bridging callus was present across the fractured part or not. It was determined by observing serial post operative X-rays. If the bridging callus was present, union status was marked "YES"; if not, it was marked "NO".
- **Union Time:** was measured as time in weeks required for bridging callus to appear after surgery.
- **Union rate:** measured by: $\frac{\text{Total fractures united in each group}}{\text{Total fractures in each group}}$

"All of these three parameters were measured for each class of group to determine the effect of third fragment (size and displacement) on union of femoral shaft fractures managed with intramedullary nailing of femur."

- Clinical and functional outcomes of fracture shaft femur (with third fragment) was measured at final follow up for both Antegrade and retrograde implant types using:

1. Modified Harris Hip score for hip functional outcome:

Table 1: Scoring used for Modified Harris Hip score [44]

	Outcome	**Score**
Modified Harris Hip score	Excellent	90-100
	Good	80-89
	Fair	70-79
	Poor	<70

Functional outcome of Hip was evaluated using Modified Harris Hip Score at the final follow-up where the score was obtained by asking the questionnaire, patient's score was calculated and then divided among four categories: Excellent (90-100), Good (80-89), Fair (70-79) and Poor (<70).

2. Oxford knee score for knee functional outcome

Table 2: Scoring used for Oxford Knee Score [45]

	Outcome	Score
Oxford Knee Score	Satisfactory knee function	40-48
	Mild to moderate knee dysfunction	30-39
	Moderate to severe knee dysfunction	20-29
	Severe knee dysfunction	0-19

Functional outcome of Knee was evaluated using Oxford Knee Score at the final follow-up where the score was obtained by asking the questionnaire, patient's score was calculated and then divided among four categories: Satisfactory(40-48), Mild to Moderate Knee Dysfunction(30-39), Moderate to Severe (20-29) and Severe (0-19).

3. VAS score for pain assessment:

   Pain was evaluated using VAS scale at the 6th month follow-up where the score was obtained by asking the patient to rate the pain from 0-10 and then dividing it into four categories: 0 (no pain), 1–3 (mild pain), 4-6 (moderate pain) and 7–10 (severe pain).[46]

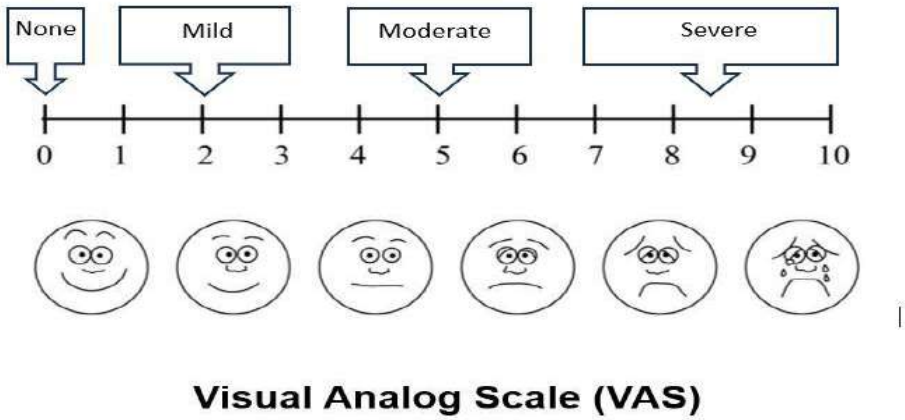

Figure 20: Visual Analog Scale (VAS)

- Re-operation rates in fracture shaft femur with third fragments was also measured by: $\frac{\text{No. of cases operated for particular complication}}{\text{Total no. of cases}} \times 100$

STATISTICAL ANALYSIS The data were described in the following formats: mean ± standard deviation (± SD), median, frequencies (number of cases), and relative frequencies (percentages), as appropriate. The Student t-test and ANOVA test were employed to compare mean values for comparing 2 groups and more then 2 groups respectively. Chi-square ($\chi 2$) test was implemented for categorical data comparison. Statistical significance was defined as a probability value (p value) that was less than 0.05. The Statistical Package for the Social Sciences (SPSS) 26 version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows was employed to conduct all statistical calculations.

OBSERVATION AND RESULTS

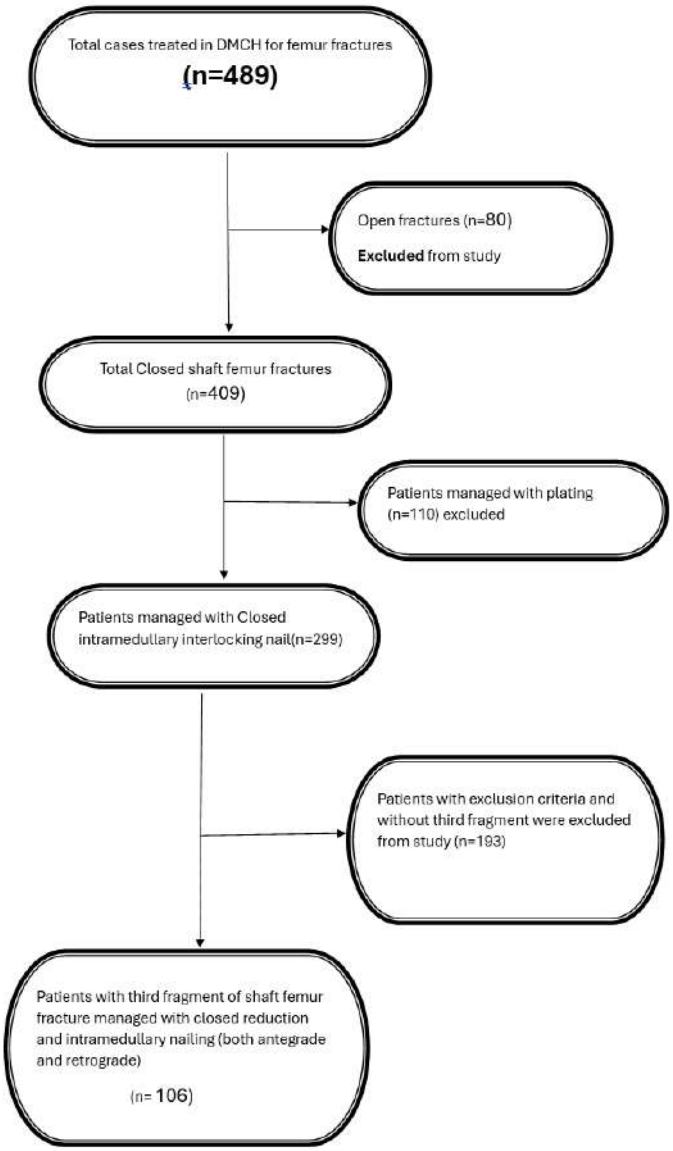

Figure 21: Consort diagram of patients selection for study

This prospective and retrospective study was conducted in the Department of Orthopaedics, DMCH Ludhiana from 1st September 2020 till 30th September 2023. During this time period a total 489 cases of femur shaft fractures presented to Hospital. Out of these cases 80 cases were open femur fractures and rest were closed fractures. Open fracture initially was managed with external fixator application. Out of rest 409 cases with closed femur fractures 110 underwent plating as fixation and 299 patients underwent nailing for fixation. In these 299 patient's different nails were used. 254 patients had fixation with AFN nail, 45 had DFN/RFN. In our study out of these nailing cases 106 patient having third fragment with shaft femur were selected for study.

Table 3: Distribution of patients with third fragment according to AGE

Age group	Frequency	Percent
18-20	17	16
21-30	41	38.7
31-40	25	23.6
41-50	11	10.4
51-60	12	11.3
Total	106	100

The majority of patients fall within the 21-30 age group, comprising 38.7% of the total 106 patients. This is followed by the 31-40 age group at 23.6%. The age groups 18-20, 41-50, and 51-60 have lower percentages at 16%, 10.4%, and 11.3%, respectively.

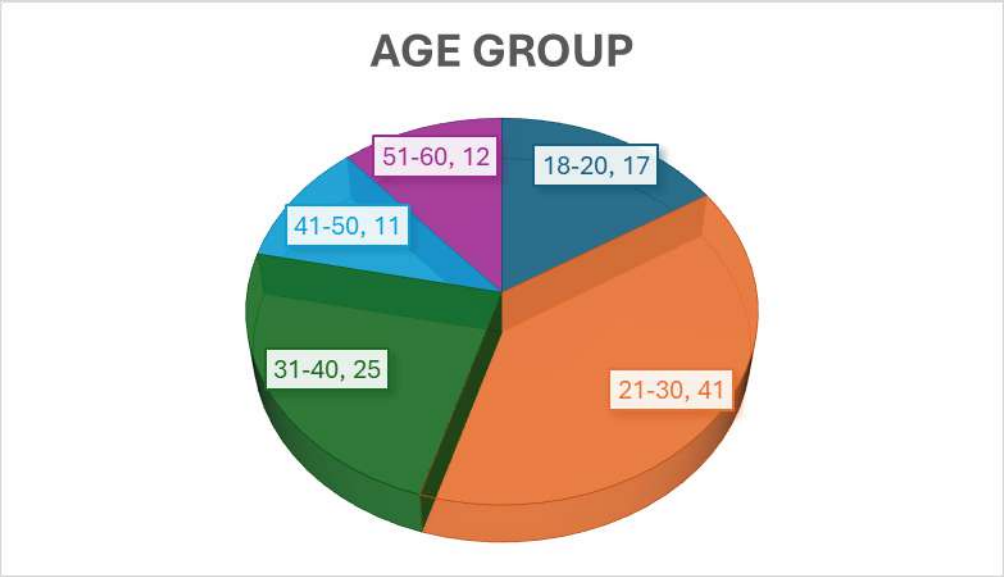

Figure 22: Distribution of patients with third fragment according to AGE

Table 4: Distribution of patients with third fragment fracture according to Gender

	Frequency	Percent
Male	90	84.9
Female	16	15.1
Total	106	100

A significant majority of the patients are male, accounting for 84.9%, while females make up 15.1%.

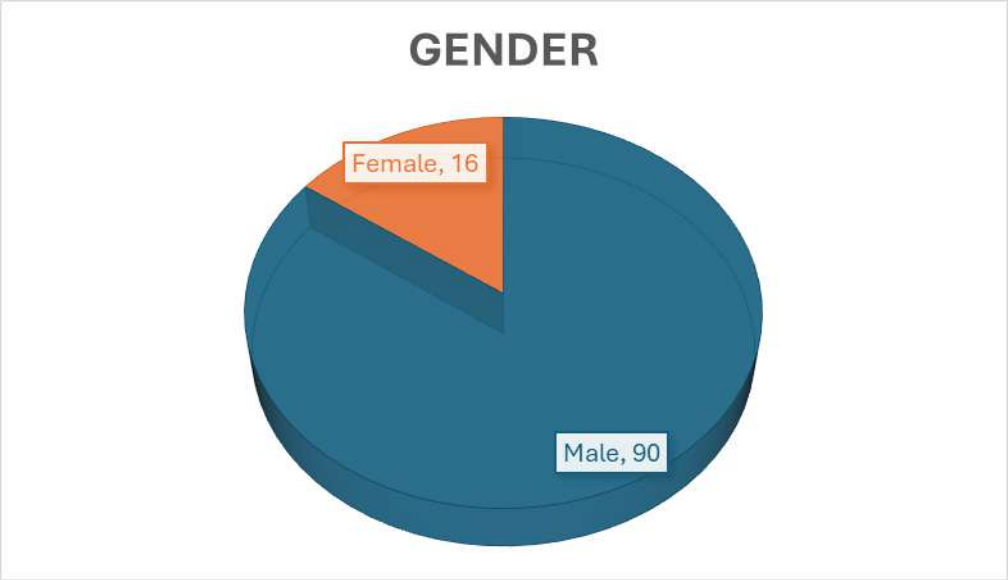

Figure 23: Distribution of patients with third fragment according to gender

Table 5: Distribution of patients with third fragment according to clinical History

Clinical history	Frequency	Percent
DOMESTIC FALL	6	5.7
RSA	100	94.3
Total	106	100

A large proportion of the patients (94.3%) sustained their fractures from road traffic accidents (RSA), whereas a small fraction (5.7%) experienced fractures due to domestic falls.

Figure 24: Distribution of patients with third fragment fracture according to clinical History

Table 6: Distribution of patients with third fragment according to side affected

Side affected	Frequency	Percent
Left	33	31.1
Right	73	68.9
Total	106	100

The right side is more frequently affected, with 68.9% of fractures occurring on this side, compared to 31.1% on the left.

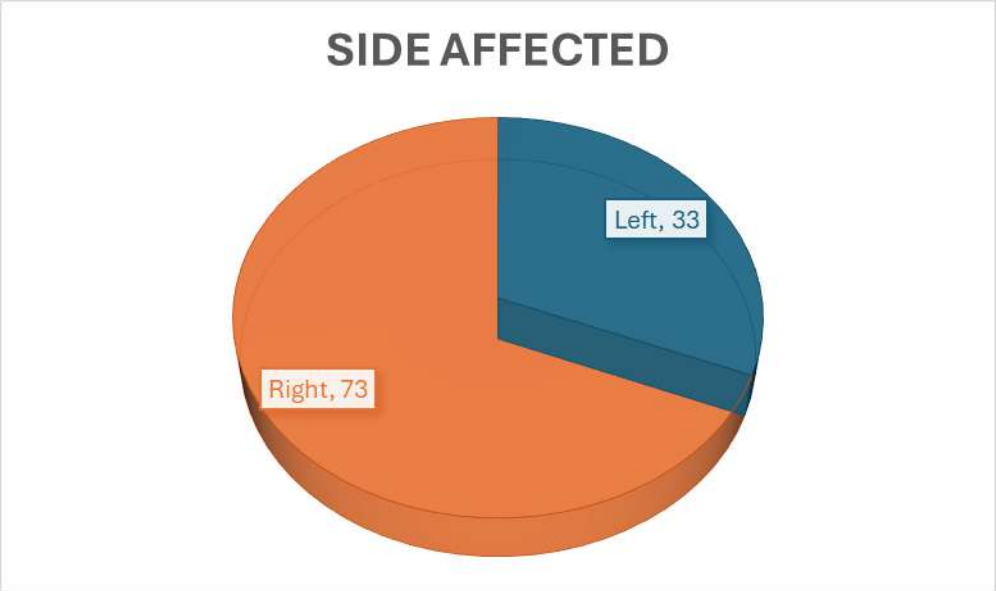

Figure 25: Distribution of patients with third fragment fracture according to side affected

Table 7: Distribution of patients with third fragment according to site of fracture

Site of fracture	Frequency	Percent
Distal shaft	18	17
Midshaft	54	50.9
Proximal shaft	34	32.1
Total	106	100

Most fractures are located at the midshaft (50.9%), followed by the proximal shaft (32.1%) and distal shaft (17%).

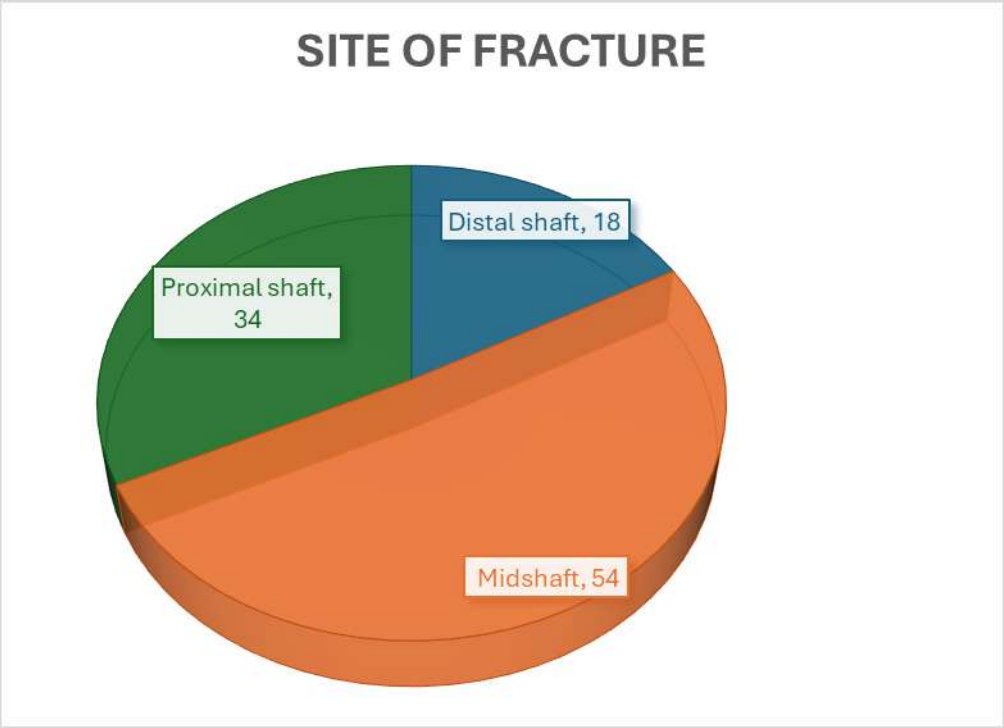

Figure 26: Distribution of patients with third fragment according to site of fracture

Table 8: Distribution of patients according to implant used

Implant used	Frequency	Percent
AFN	91	85.8
DFN/RFN	15	14.2
Total	106	100.0

The data shows that among the 106 cases, AFN implants were more frequently used, accounting for 85.8% (91 cases), while DFN implants were used in only 14.2% (15 cases). This indicates a strong preference or clinical indication for the use of AFN implants in the majority of patients.

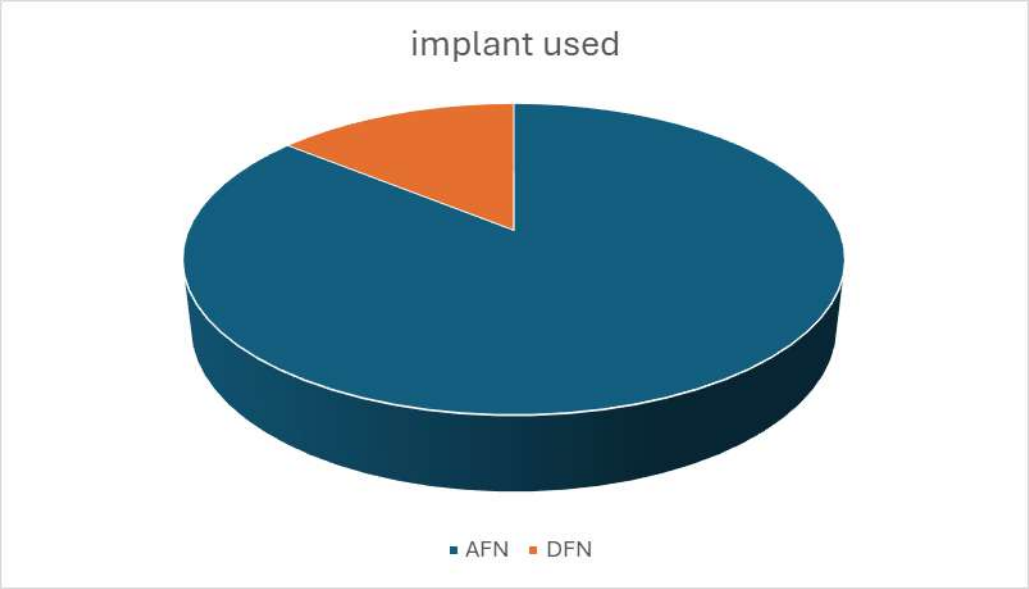

Figure 27: Distribution of patients according to implant used

Table 9: Distribution of patients with third fragment according to AO/OTA Fracture Class

AO/OTA Fracture Class		Frequency	Percent	Frequency	Percent
32B	32B2	65	61.3	85	80.2
	32B3	20	18.9		
32C	32C2	6	5.7	21	19.8
	32C3	15	14.2		
Total	Total	106	100	106	100

The most common classification is 32B, particularly 32B2 (61.3%) and 32B3 (18.9%), making up 80.2% of the total. The 32C classification includes 32C2 (5.7%) and 32C3 (14.2%), representing 19.8%.

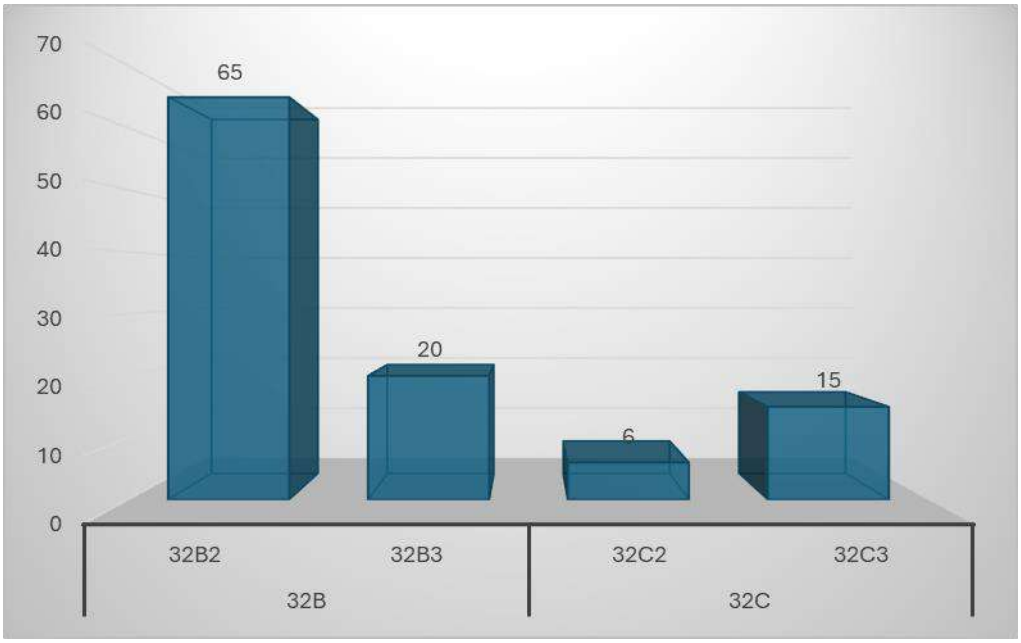

Figure 28: Distribution of patients with third fragment fracture according to AO/OTA Fracture Class

Comparison of fracture union according to fracture type

Table 10: Comparison of fracture union rate and fracture type (32B and 32C AO/OTA)

	union						Chi-square	p-value
	absent		present					
	N	%	N	%	N	%		
32B	7	8.20%	78	91.80%	85	100.00%	2.117[a]	0.146
32c	4	19.00%	17	81.00%	21	100.00%		
	11	10.40%	95	89.60%	106	100.00%		

The data presented compares the union rates and union times between two types of fractures, 32B and 32C(AO/OTA). In terms of union rates, 91.8% of cases of fracture type 32B achieved union, while 81% of fracture type 32C cases achieved the same outcome. Despite these differences, the chi-square analysis revealed a non-significant association between union rate and fracture type ($\chi^2 = 2.117$, $p = 0.146$), indicating that the likelihood of achieving union does not significantly differ between the two fracture types.

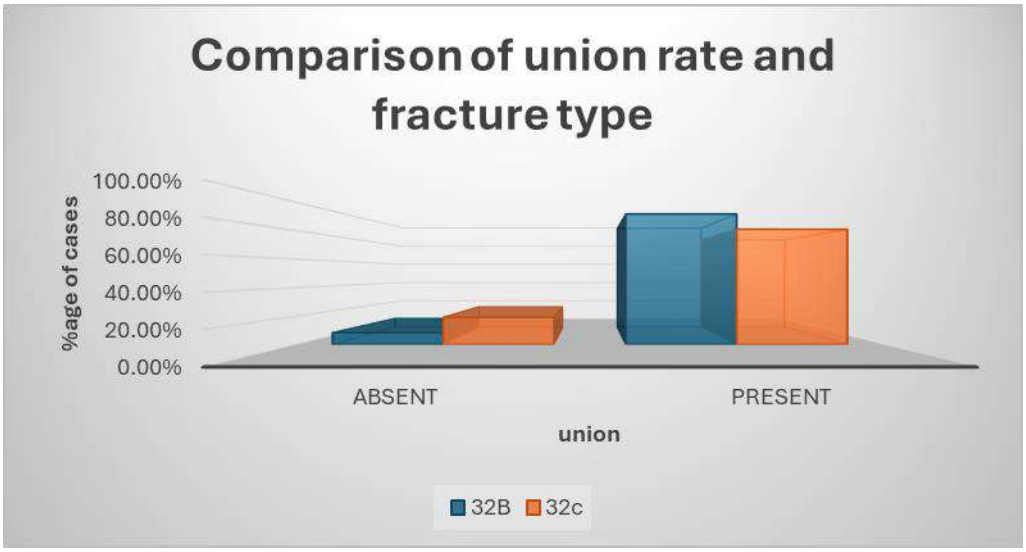

Figure 29: Comparison of fracture union rate and fracture type (32B and 32C AO/OTA)

Table 11: Comparison of union time with respect to fracture type (32B and 32C AO/OTA)

Fracture classification	Number of cases	Mean Union time(weeks)	Std. Deviation	T test	p-value
32B	78	16.1	3.189	0.122	0.903
32C	17	16	2.828		

The comparison of mean union times showed minimal variation: fracture type 32B had a mean union time of 16.1 weeks with a standard deviation of 3.189 weeks, while fracture type 32C had a mean union time of 16 weeks with a standard deviation of 2.828 weeks. The t-test analysis confirmed that there is no statistically significant difference in mean union times between fracture types 32B and 32C ($t = 0.122$, $p = 0.903$). These findings suggest that, clinically, both fracture types exhibit comparable outcomes in terms of union rates and the time required for union to occur, implying similar management and treatment strategies may be effective for both types.

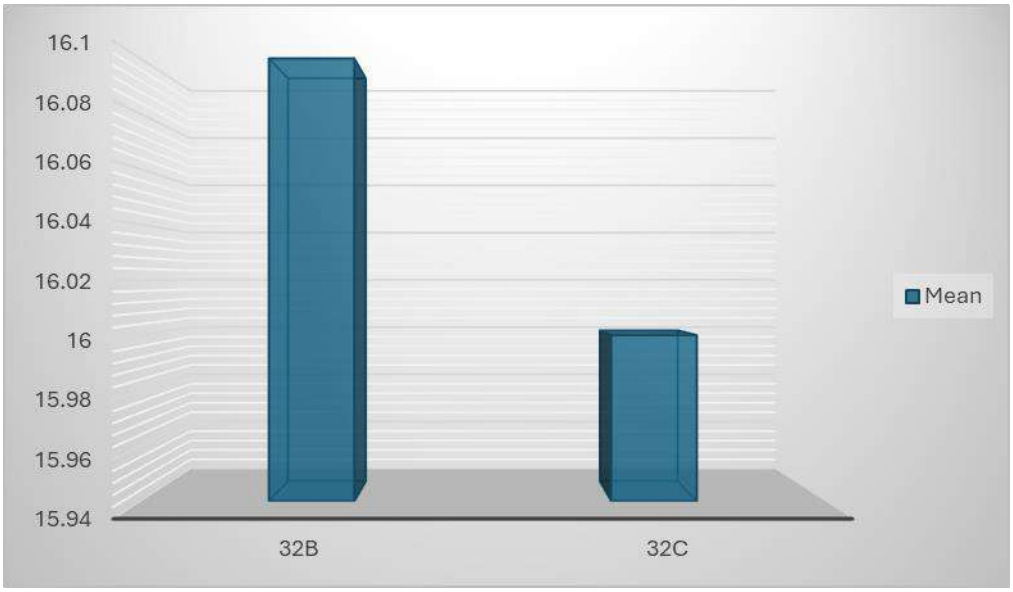

Figure 30: Comparison of union time with respect to fracture type (32B and 32C AO/OTA)

Table 12: Association of fracture union rate and fracture subtypes (32B2 and 32B3 AO/OTA)

	union						Chi-square	p-value
	absent		present					
	n	%	N	%	n	%		
32B2	3	4.60%	62	95.40%	65	100.0%	4.790[a]	0.029
32B3	4	20.00%	16	80.00%	20	100.0%		
	7	8.20%	78	91.80%	85	100.0%		

The table compares the presence or absence of union (absent vs. present) between two subtypes of fracture type 32B (32B2 and 32B3). The chi-square test shows a significant association ($\chi^2 = 4.790$, $p = 0.029$), indicating that the union rate differs significantly between 32B2 and 32B3. Specifically, 95.4% of cases in 32B2 achieved union compared to 80% in 32B3. This suggests that the subtype of fracture within type 32B may influence the likelihood of successful union following treatment.

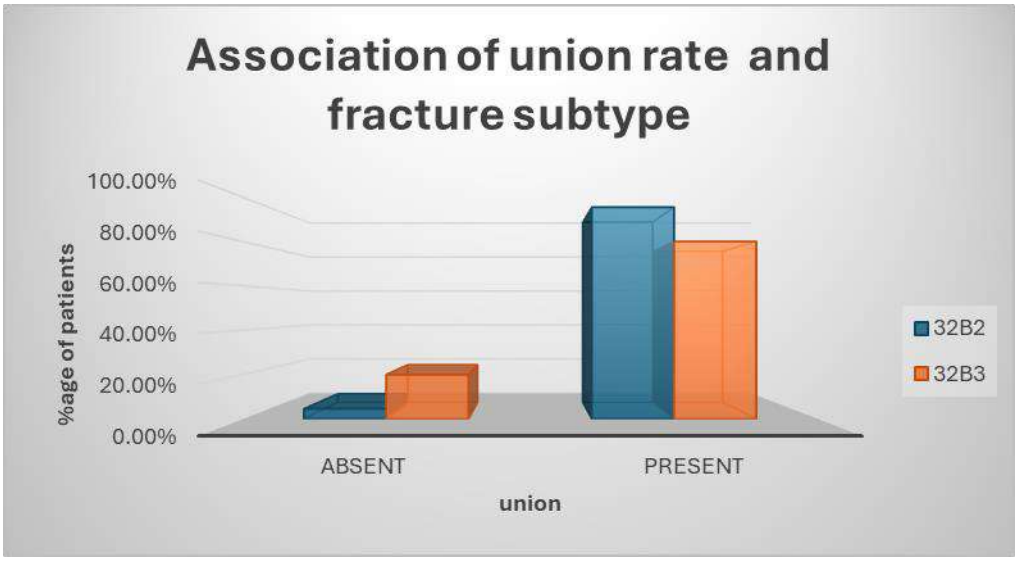

Figure 31: Association of fracture union rate and fracture subtype (32B2 and 32B3)

Table 13: Comparison of fracture union time and fracture subtype (32B2 and 32B3)

Fracture classification	N	Mean Union time(weeks)	Std. Deviation	T test	p-value
32B2	62	16.26	3.289	0.846	0.4
32B3	16	15.5	2.781	0.695	

When comparing the mean union times between 32B2 (Mean = 16.26 weeks) and 32B3 (Mean = 15.5 weeks), the t-test shows no significant difference (t = 0.846, p = 0.4). This indicates that although there is a difference in union rates, this does not correspond to a significant difference in the time it takes for union to occur between these subtypes of fracture type 32B.

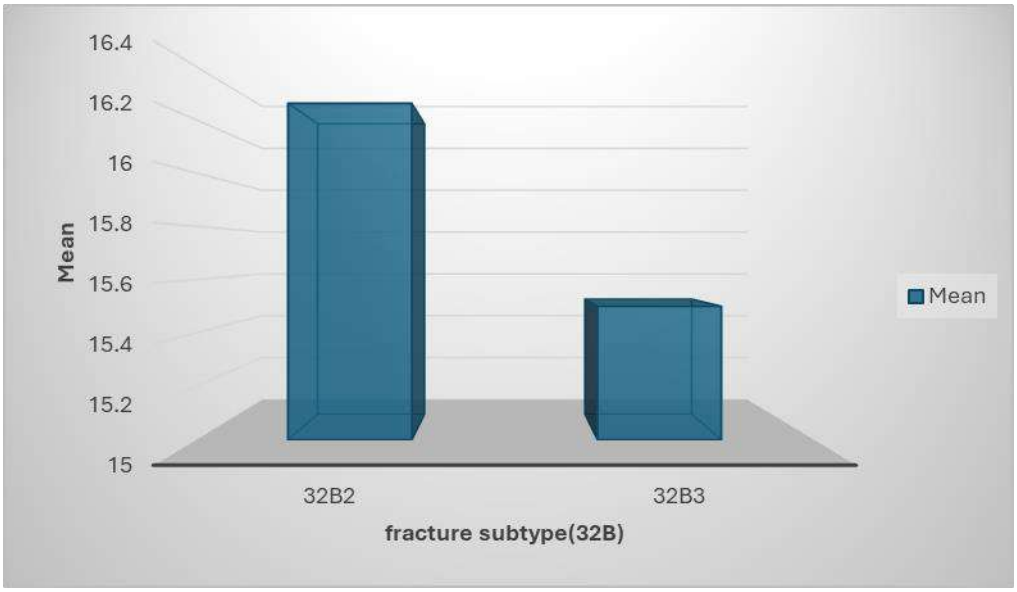

Figure 32: Comparison of fracture union time and fracture subtype (32B2 and 32B3)

Table 14: Association of fracture union rate and fracture subtype (32C2 and 32C3)

	union						Chi-square	p-value
	absent		present					
	N	%	N	%	n	%		
32C2	1	16.70%	5	83.30%	6	100.00%	2.117	0.146
32C3	3	20.00%	12	80.00%	15	100.00%		
	4	19.00%	17	81.00%	21	100.00%		

In this table, the association between union rate and fracture type is examined for subtypes 32C2 and 32C3. The chi-square test shows no significant association ($\chi^2 = 2.117$, $p = 0.146$), suggesting that there is no statistically significant difference in union rates between these two subtypes of fracture type 32C. This implies that the likelihood of achieving union following treatment is similar for both 32C2 and 32C3 fractures.

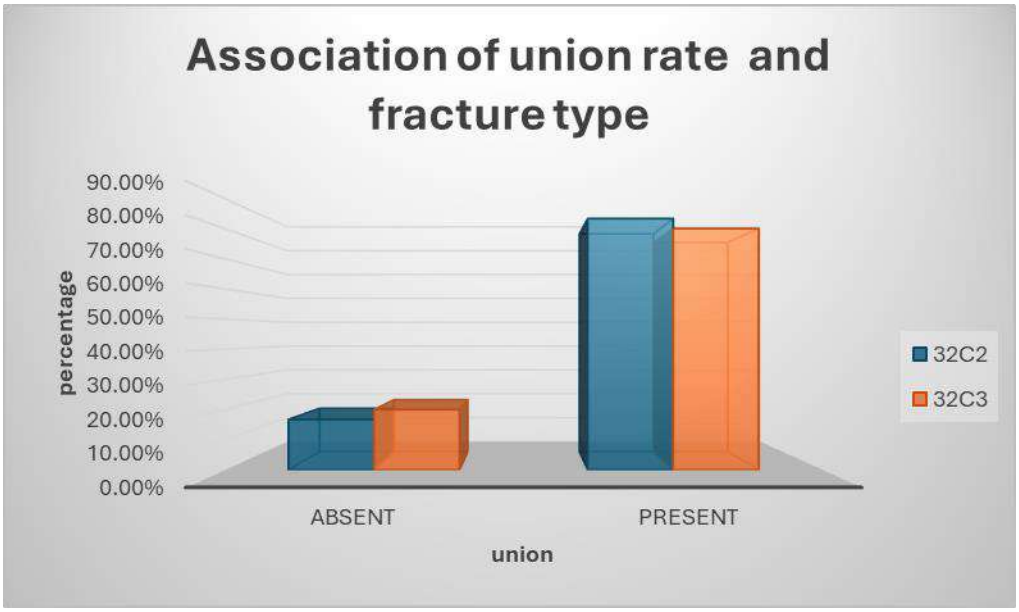

Figure 33: Association of fracture union rate and fracture subtype (32C2 and 32C3)

Table 15: Comparison of fracture union time and fracture subtype (32C2 and 32C3)

Fracture Classification	N	Mean Union time(weeks)	Std. Deviation	t-value	p-value
32C2	5	15.2	1.789	-0.742	0.469
32C3	12	16.33	3.172	0.916	

Similarly, the comparison of mean union times between 32C2 (Mean = 15.2 weeks) and 32C3 (Mean = 16.33 weeks) reveals no significant difference (t = -0.742, p = 0.469). This indicates that while there may be no statistical difference in union rates between subtypes 32C2 and 32C3, there is also no significant difference in the time it takes for union to occur.

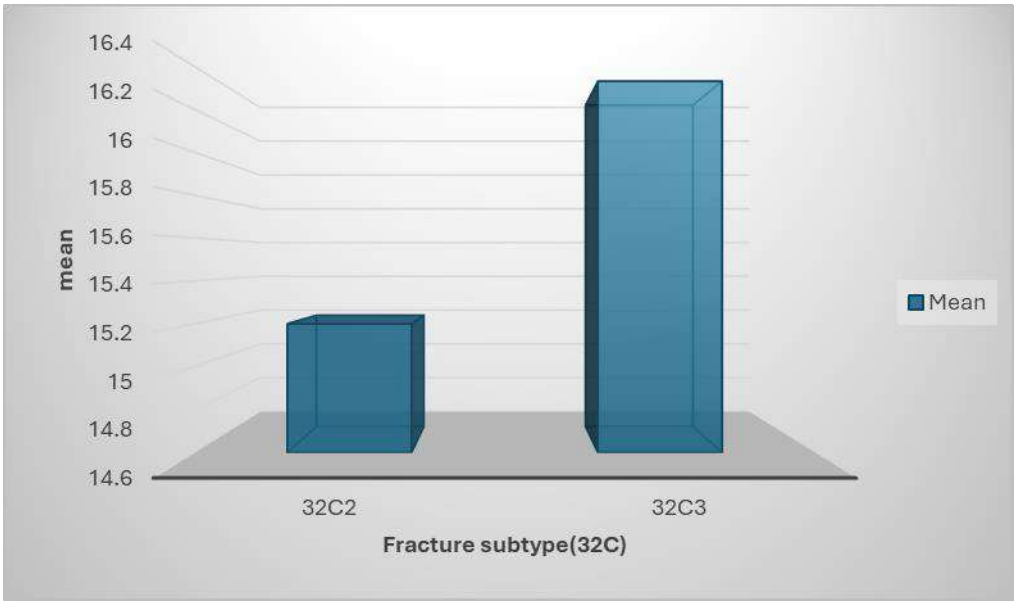

Figure 34: Comparison of fracture union time and fracture type (32C2 and 32C3)

Table 16: Association of fracture union rate and Segment of fracture

	Union						Chi-square	p-value
	Absent		Present					
	n	%	N	%	n	%		
Distal shaft	2	11.11%	16	88.89%	18	100.0%	1.13	0.55
Midshaft	7	12.96%	47	87.04%	54	100.0%		
Proximal shaft	2	6.25%	32	94.12%	34	32.10%		
Total	11	10.38%	95	89.62%	106	100.0%		

The union status, categorized as either "Union Absent" or "Union Present," is determined for each shaft location. For distal shaft fractures, 11.11% (2 out of 18) had non union, while 88.89% (16 out of 18) achieved union. Midshaft fractures showed a similar trend, with 12.96% (7 out of 54) having non union and 87.04% (47 out of 54) achieving union. Proximal shaft fractures had the lowest absence of union at 6.25% (2 out of 34), with 94.12% (32 out of 34) achieving union. Overall, 10.38% (11 out of 106) of the fractures had non union, while 89.62% (95 out of 106) achieved union. The Chi-square test resulted in a value of 1.13, and the p-value was 0.55, indicating no statistically significant difference in union rates across the different shaft locations.

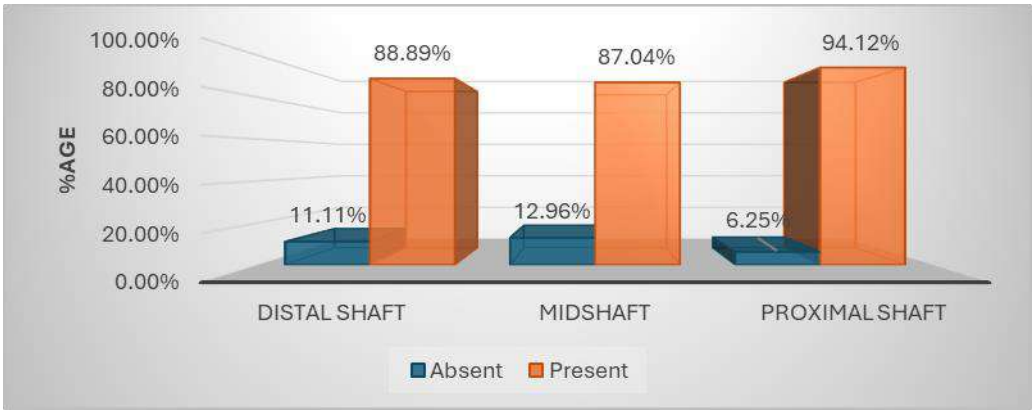

Figure 35: Association of fracture union rate and Segment of fracture

Table 17: Comparison of fracture union time and segment of fracture

Site	N	Mean Union Time(weeks)	Std. Deviation	F-value	p-value
Distal shaft	16	16.50	3.225	0.43	0.64
Midshaft	47	16.21	2.956		
Proximal shaft	32	15.69	3.335		

Regarding union times, the mean durations varied slightly across the fracture sites. Distal shaft fractures had a mean union time of 16.50 weeks, midshaft fractures averaged 16.21 weeks, and proximal shaft fractures averaged 15.69 weeks. The analysis using an F-test to compare the variance in union times across these sites yielded a non-significant result (F = 0.43, p = 0.64). This indicates that while there are slight differences in mean union times, these differences are not statistically significant.

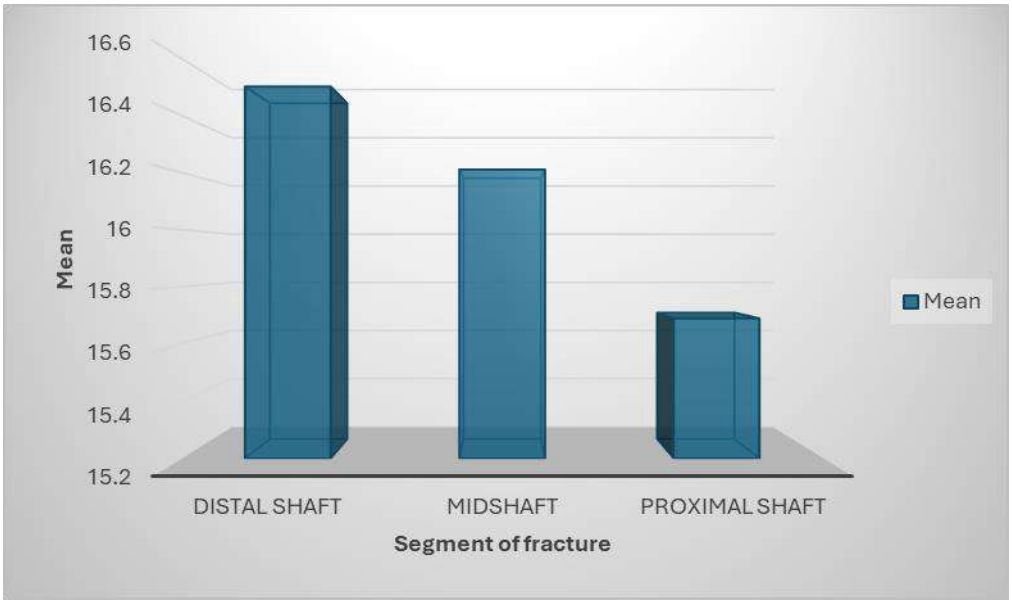

Figure 36: Comparison of fracture union time and segment of fracture

FRAGMENT SIZE

Table 18: Distribution of the patient groups with respect to fragment size according to axis length

Fragment Size Groups	Frequency	Percent
Group A (0-3.9 cm)	47	44.3
Group B (4-7.9 cm)	26	24.5
Group C (8 or >8 cm)	33	31.1
Total	106	100.0

The data on third fragment fractures based on fragment size reveals distinct groupings among the 106 patients. Group A, comprising those with fragment sizes between 0-3.9 cm, constitutes the largest group at 44.3% (47 patients). Group B, with fragment sizes between 4-7.9 cm, includes 24.5% (26 patients) of the total. Group C, representing fragments 8 cm or larger, makes up 31.1% (33 patients). Overall, this distribution provides a clear picture of the prevalence of different fragment sizes in third fragment fractures.

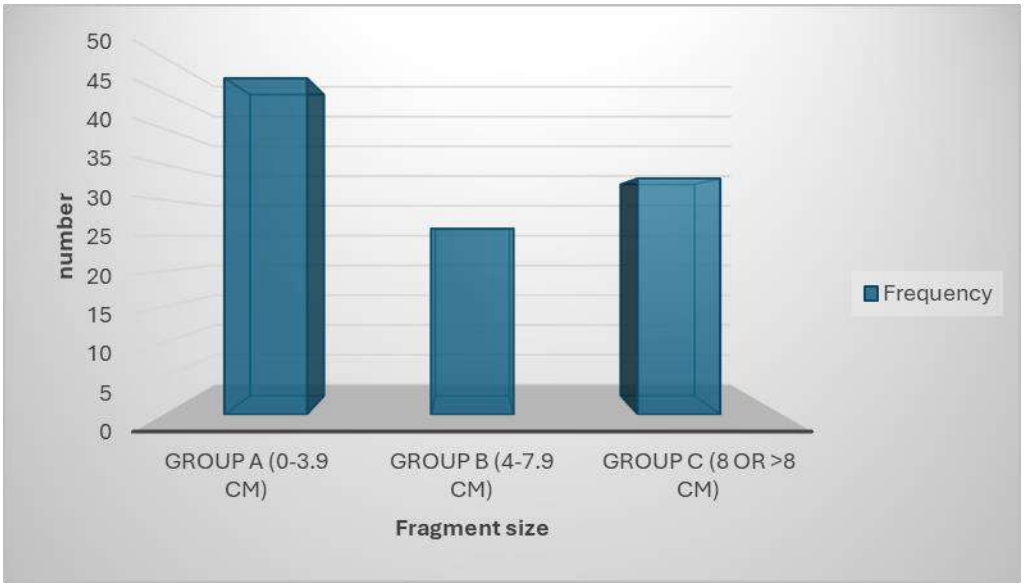

Figure 37: Distribution of the patient groups with respect to fragment size according to axis length

Table 19: Association of Fragment size according to axis length with fragment Displacement proximally

Proximal displacement	Fragment size according to axis length				Chi-Square	p-value
	Group A (0-3.9 cm)	Group B (4-7.9 cm)	Group C (8 or >8 cm)	Total		
	n (%)	n (%)	n (%)	n (%)		
P1 (0–9 mm)	22 (46.8%)	12 46.2%)	14 (42.4%)	48 (45.3%)	1.407	0.965
P2 (10-19 mm)	19 (40.4%)	11 (42.3%)	14 (42.4%)	44 (41.5%)		
P3 (20-29 mm)	3 (6.4%)	2 (7.7%)	4 (12.1%)	9 (8.5%)		
P4 (30-39 mm)	3 (6.4%)	1 (3.8%)	1 (3.0%)	5 (4.7%)		
Total	47 (100.0%)	26 (100.0%)	33 (100.0%)	106 (100.0%)		

The table presents the distribution of proximal displacement by fragment size according to axis length, expressed in percentages. Group A (0-3.9 cm) shows that 46.8% of the patients had a proximal displacement of P1 (0–9 mm), 40.4% had P2 (10-19 mm), 6.4% had P3 (20-29 mm), and 6.4% had P4 (30-39 mm). In Group B (4-7.9 cm), 46.2% of the patients had P1 displacement, 42.3% had P2, 7.7% had P3, and 3.8% had P4. Group C (8 or >8 cm) reveals that 42.4% had P1 displacement, another 42.4% had P2, 12.1% had P3, and 3.0% had P4. Overall, across all groups, 45.3% of the patients had P1 proximal displacement, 41.5% had P2, 8.5% had P3, and 4.7% had P4. Each group's percentages sum to 100%, reflecting the total distribution within each fragment size category.

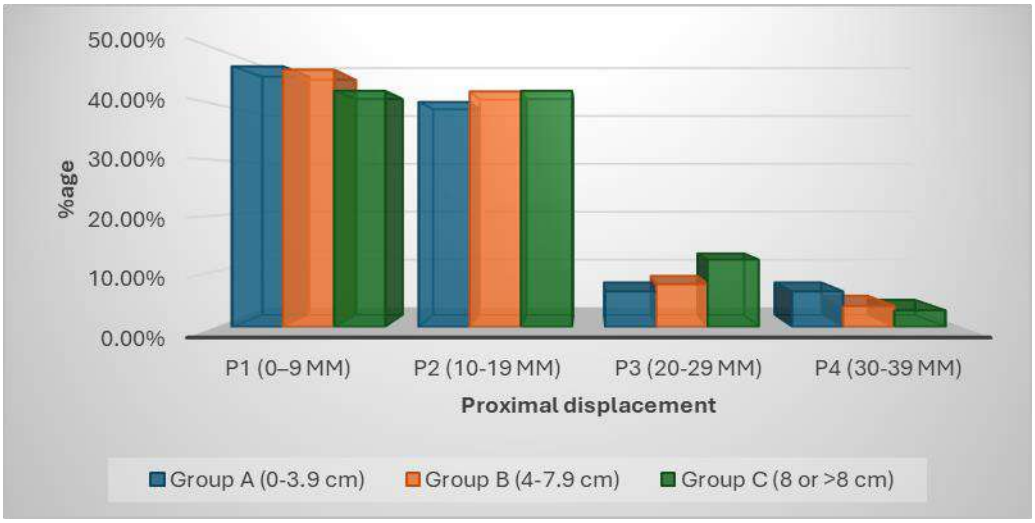

Figure 38: Association of Fragment size according to axis length with fragment Displacement proximal

Table 20: Comparison of Fragment size according to axis length with Mean Proximal displacement

Third Fragment Characteristics	Group A (0-3.9 cm) Mean ± SD	Group B (4-7.9 cm) Mean ± SD	Group C (≥8 cm) Mean ± SD	f-value	p-value
Proximal Displacement (mm)	12.84 ± 9.25	12.37 ± 7.56	13.02 ± 9.01	0.04	0.96

The table compares the mean proximal displacement (measured in millimetres) across three groups based on fragment size according to axis length. Group A (0-3.9 cm) has a mean proximal displacement of 12.84 mm, Group B (4-7.9 cm) has a mean displacement of 12.37 mm, and Group C (≥8 cm) has a mean displacement of 13.02 mm. The f-value for the comparison is 0.04, and the p-value is 0.96, indicating no statistically significant difference in proximal displacement among the three groups.

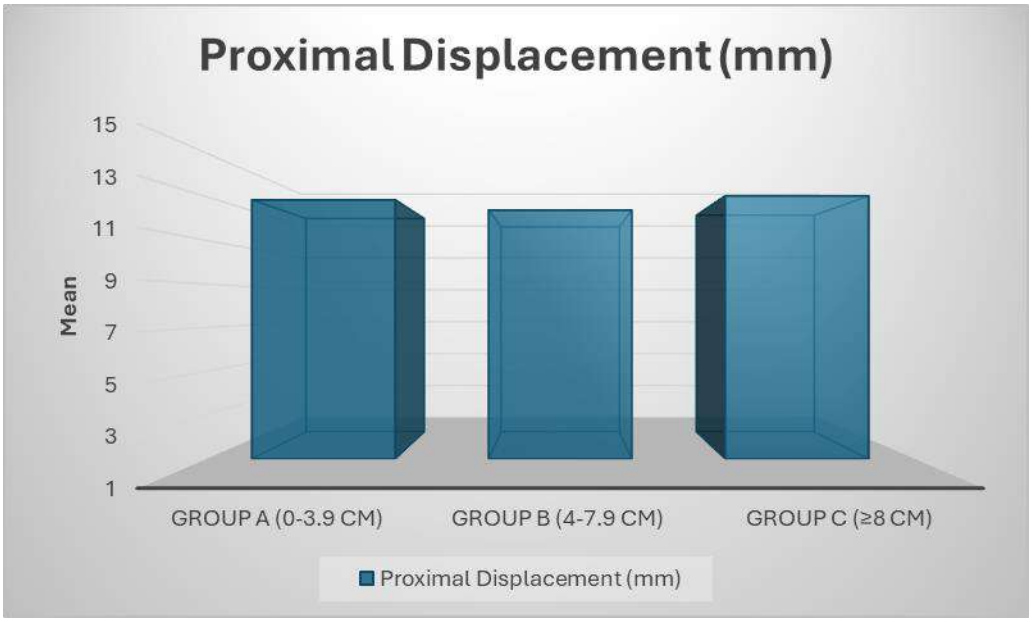

Figure 39: Comparison of Fragment size according to axis length with Mean proximal displacement.

Table 21: Association of Fragment size according to axis length with fragment Displacement distally

Distal displacement	Fragment size				Chi-Square	p-value
	Group A (0-3.9 cm)	Group B (4-7.9 cm)	Group C (8 or >8 cm)	Total		
	n (%)	n (%)	n (%)	n (%)		
D1 (0–9 mm)	22 (46.8%)	11 (42.3%)	10 (30.3%)	43 (40.6%)	3.218	0.781
D2 (10-19 mm)	18 (38.3%)	10 (38.5%)	15 (45.5%)	43 (40.6%)		
D3 (20-29 mm)	4 (8.5%)	2 (7.7%)	5 (15.2%)	11 (10.4%)		
D4 (30-39 mm)	3 (6.4%)	3 (11.5%)	3 (9.1%)	9 (8.5%)		
Total	47 (100.0%)	26 (100.0%)	33 (100.0%)	106 (100.0%)		

The table displays displacement fragment displacement categorized by size groups (Group A, Group B, and Group C) and includes statistical measures. Each cell represents the count and percentage of fragments in specific distal displacement (D1-D4) and size categories. For example, Group A (0-3.9 cm) shows 22 fragments (46.8%) with D1 displacement, 18 fragments (38.3%) with D2, 4 fragments (8.5%) with D3, and 3 fragments (6.4%) with D4.

The Chi-Square (3.218) and p-value (0.781) indicate the association between fragment size and distal displacement. With a p-value of 0.781 (>0.05), the table suggests that fragment size may not significantly influence distal displacement in this dataset.

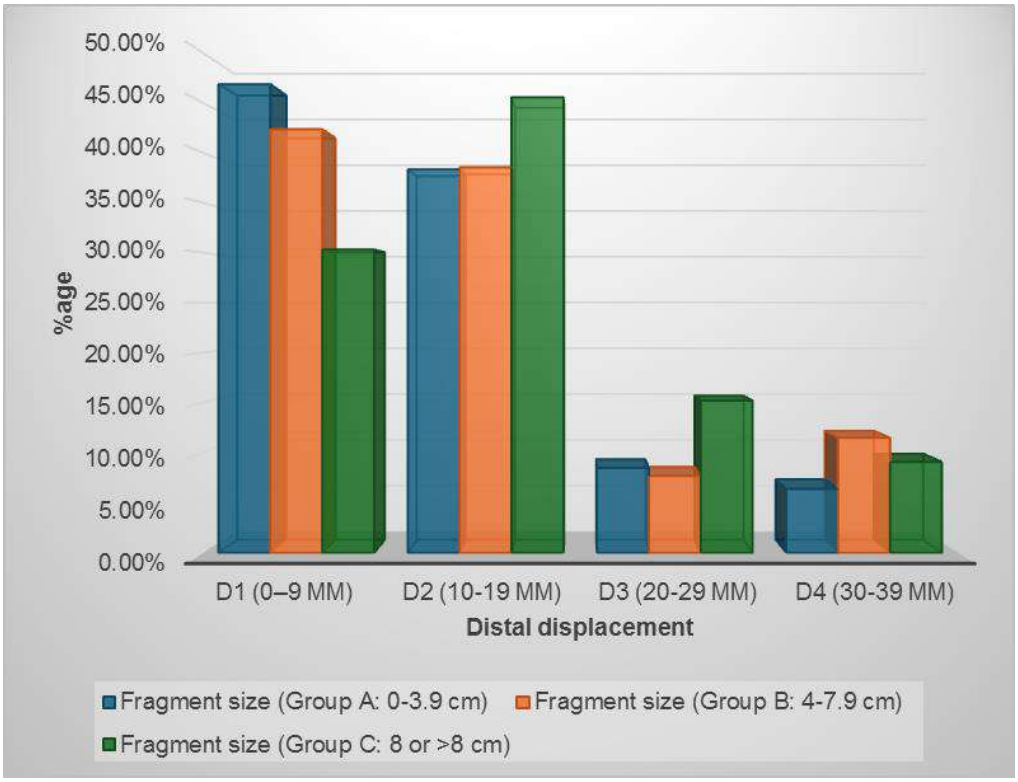

Figure 40: Association of Fragment size according to axis length with fragment Displacement distally

Table 22: Comparison of Fragment size according to axis length with Mean distal displacement of fragment

Third Fragment Characteristics	Group A (0-3.9 cm) Mean ± SD	Group B (4-7.9 cm) Mean ± SD	Group C (≥8 cm) Mean ± SD	f-value	p-value
Distal Displacement (mm)	12.80 ± 9.79	15.07 ± 14.45	16.33 ± 11.06	0.97	0.38

The table compares the mean distal displacement (measured in millimeters) across three groups based on fragment size according to axis length. Group A (0-3.9 cm) has a mean distal displacement of 12.80 mm, Group B (4-7.9 cm) has a mean displacement of 15.07 mm, and Group C (≥8 cm) has a mean displacement of 16.33 mm. The f-value for the comparison is 0.97, and the p-value is 0.38, indicating no statistically significant difference in distal displacement among the three groups.

Figure 41: Comparison of Fragment size according to axis length with Mean distal displacement of fragment

Table 23: Comparison of fracture union rate with Fragment size according to axis length

Union	Fragment size				Chi-Square	p-value
	Group A (0-3.9 cm)	Group B (4-7.9 cm)	Group C (8 or >8 cm)	Total		
	n (%)	n (%)	n (%)	n (%)		
No	2 (4.30%)	3 (11.50%)	6 (18.20%)	11 (10.40%)	4.09	0.129
Yes	45 (95.70%)	23 (88.50%)	27 (81.80%)	95 (89.60%)		
Total	47 (100.0%)	26 (100.0%)	33 (100.0%)	106 (100.0%)		

The table compares the union rates of fragments categorized by size groups (Group A, Group B, and Group C). It shows the percentage of fractures with fragment achieving union ("Yes") and not achieving union ("No") within each size category. For example, in Group A (0-3.9 cm), 95.70% of fractures achieved union, while 4.30% did not. The Chi-Square test with a p-value of 0.129 indicates that there is no significant association between fragment size (axis length categories) and union status based on the data provided.

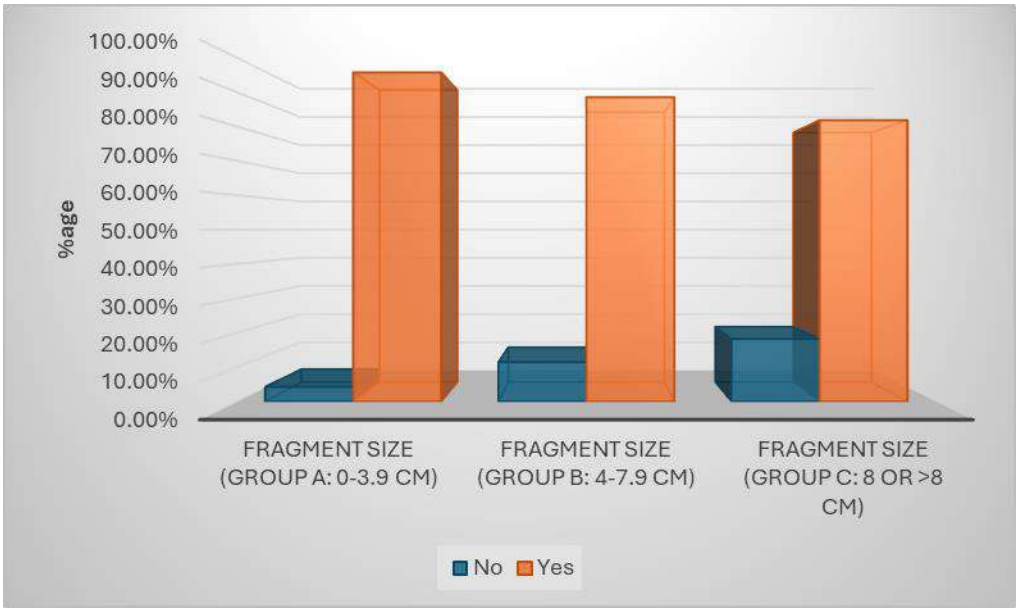

Figure 42: Comparison of fracture union rate with Fragment size according to axis length

Table 24: Comparison of fracture union time with Fragment size according to axis length

	Group A (0-3.9 cm) Mean ± SD	Group B (4-7.9 cm) Mean ± SD	Group C (≥8 cm) Mean ± SD	f-value	p-value
Union time (weeks)	15.24 ± 2.84	16.70 ± 2.87	16.96 ± 3.48	3.31	0.04

The table provides a comparison of Union time in weeks among fragments categorized into three size groups: Group A (0-3.9 cm), Group B (4-7.9 cm), and Group C (≥8 cm). Union time refers to the average duration it took for fracture to achieve union, with standard deviations (SD) indicating the variability around the mean time within each group. Specifically, fragments in Group A had an average Union time of 15.24 weeks, with an SD of 2.84 weeks, while Group B fragments averaged 16.70 weeks (SD 2.87 weeks), and Group C averaged 16.96 weeks (SD 3.48 weeks). this table indicates that there is a statistically significant difference in Union time among fractures with fragments of different sizes, as determined by their axis lengths categorized into Group A, Group B, and Group C.

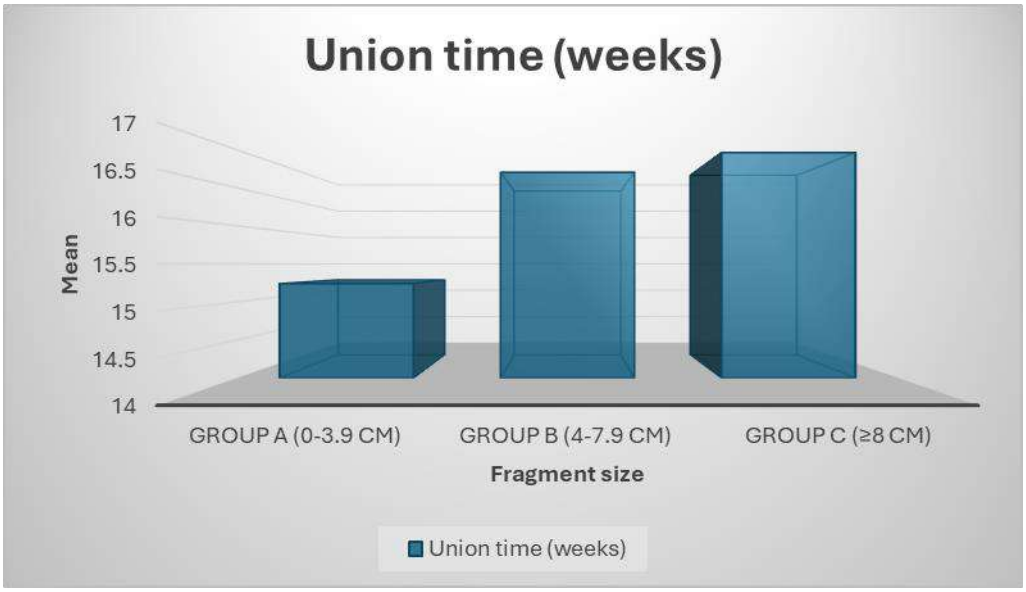

Figure 43: Comparison of union time with Fragment size according to axis length

FRAGMENT DISPLACEMENT

Table 25: Distribution of the patient groups with small and large gap (Lin et al. [8] Method)

	Frequency	Percent
Large gap	21	19.8
Small gap	85	80.2
Total	106	100.0

In the present study if the calculated gap was >10 mm between the butterfly fragment and reduced shaft were designated as the large-gap group, and those with a gap =<10 mm as the small-gap group. We observed total 21 patients (19.8%) with large gap and 85(80.2%) with small gaps.

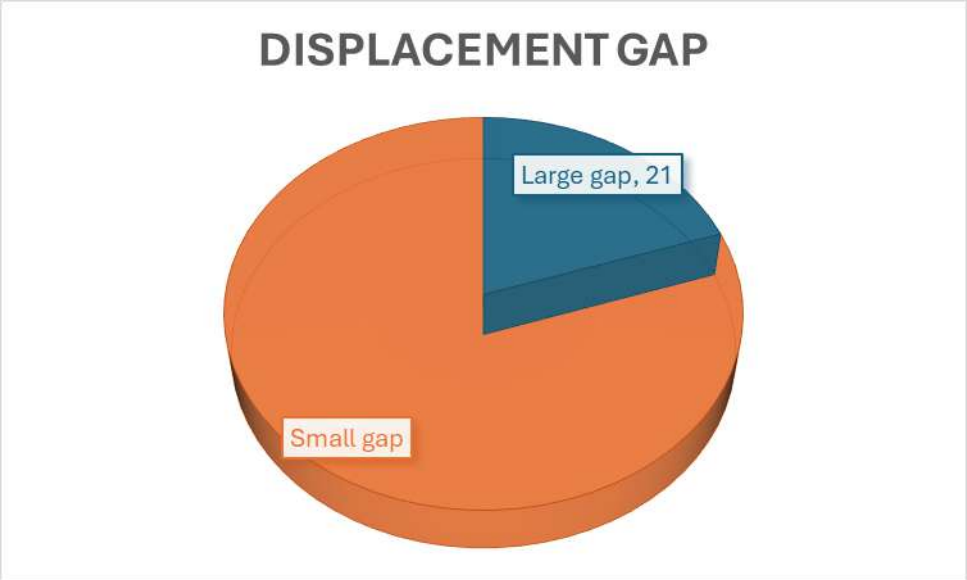

Figure 44: Distribution of the patient groups with small and large gap (Lin et al. [8] Method).

Table 26: Grouped data comparison of displacement by Lin method with third fragment size

Characteristic	Small Gap Mean ± SD	Large Gap Mean ± SD	t-test (independent)	p-value
Fragment Size (cm)	6.21 ± 4.60	7.28 ± 5.68	-0.91	0.37

For Small Gap, the mean fragment size is 6.21 cm with a SD of 4.60 cm, while for Large Gap, the mean fragment size is 7.28 cm with a SD of 5.68 cm. A t-test for independent samples was conducted to assess whether there is a statistically significant difference between the mean fragment sizes of these two groups. The t-test resulted in a t-value of -0.91 and a p-value of 0.37. This p-value suggests that there is no statistically significant difference in mean fragment sizes between the Small Gap and Large Gap groups at the conventional significance level of 0.05

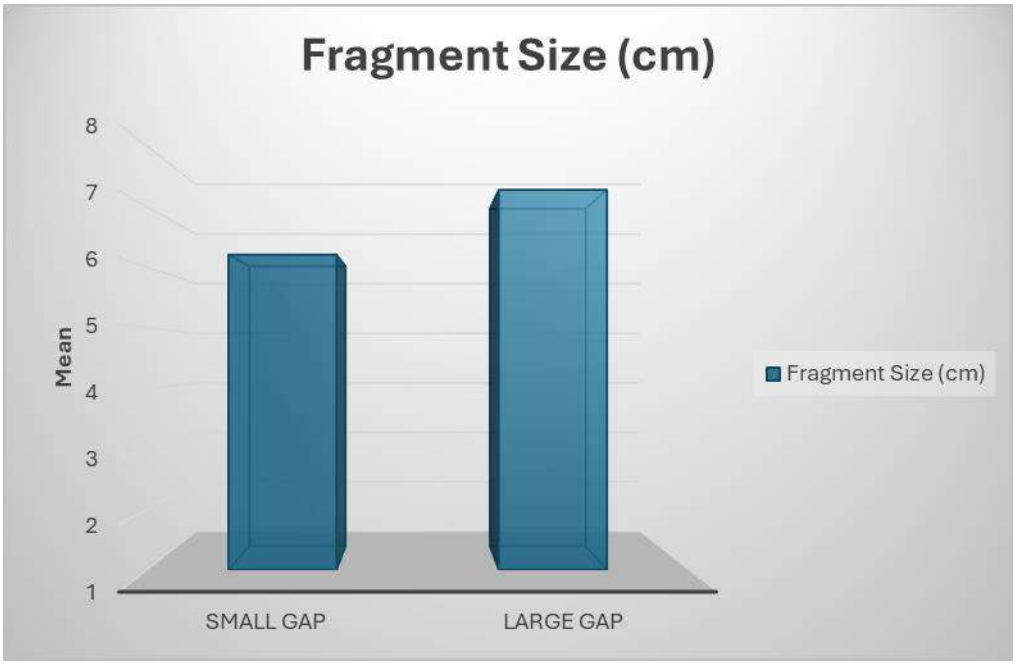

Figure 45: Grouped data comparison of displacement by Lin method with third fragment size

Table 27: Comparison of union rate among patients according to fragment displacement (Lin method)

Union	Displacement using the Lin method						chi-square	p-value
	small Gap		Large gap		Total			
	N	%	n	%	n	%		
No	10	11.80%	1	4.80%	11	10.40%	.88	0.346
Yes	75	88.20%	20	95.20%	95	89.60%		
Total	85	100.00%	21	100.00%	106	100.00%		

The comparison of patients according to fragment displacement using the Lin method showed that among those who did not achieve union, 11.80% had a small gap, while only 4.80% had a large gap, totaling 10.40% of the overall sample. Conversely, among patients who achieved union, 88.20% had a small gap, and 95.20% had a large gap, accounting for 89.60% of the total sample. The chi-square test yielded a value of 0.88 with a p-value of 0.346. This indicates no statistically significant association between the union status and the size of the fragment displacement (small gap vs. large gap) according to the Lin method. The observed differences in union status between the small and large gap groups are likely due to random variation.

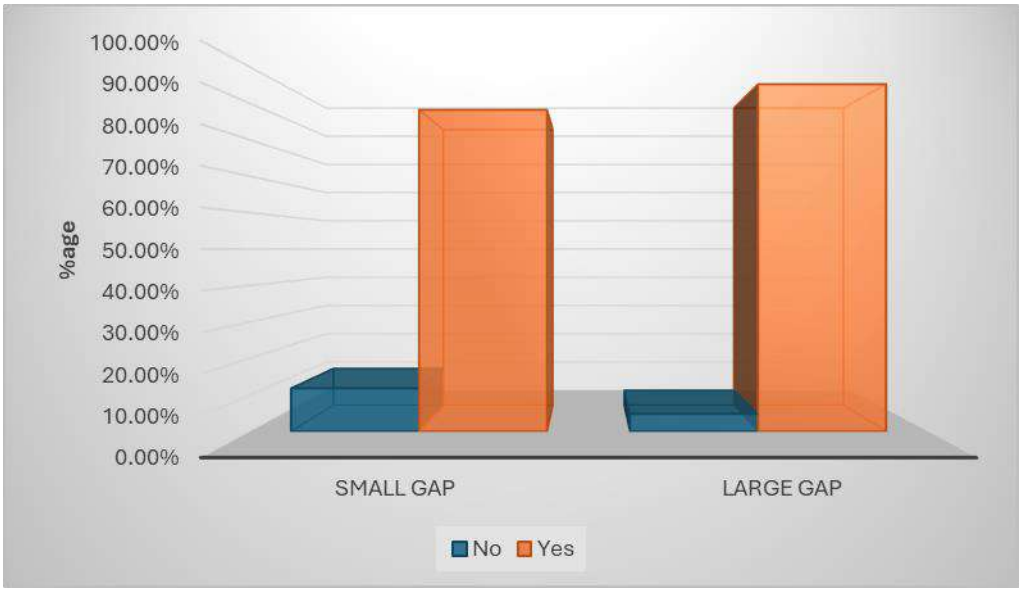

Figure 46: Comparison of union rate among patients according to fragment displacement (Lin method)

Table 28: Comparison of union time among patients categorized by Fragment displacement by the Lin method

Characteristic	Small Gap Mean ± SD	Large Gap Mean ± SD	t-test (independent)	p-value
Union time (weeks)	15.68 ± 3.03	17.60±3.02	-2.52	0.01

The mean union time for patients with a small gap was 15.68 weeks (±3.03 weeks), whereas for patients with a large gap, the mean union time was 17.60 weeks (±3.02 weeks). The independent t-test results showed a t-value of -2.52 and a p-value of 0.01, indicating a statistically significant difference in union time between the two groups. This suggests that patients with large gaps experienced a significantly longer mean union time compared to those with small gaps. The p-value of 0.01 confirms that this difference is unlikely to be due to random chance and reflects a true difference in union times based on the size of the fragment displacement.

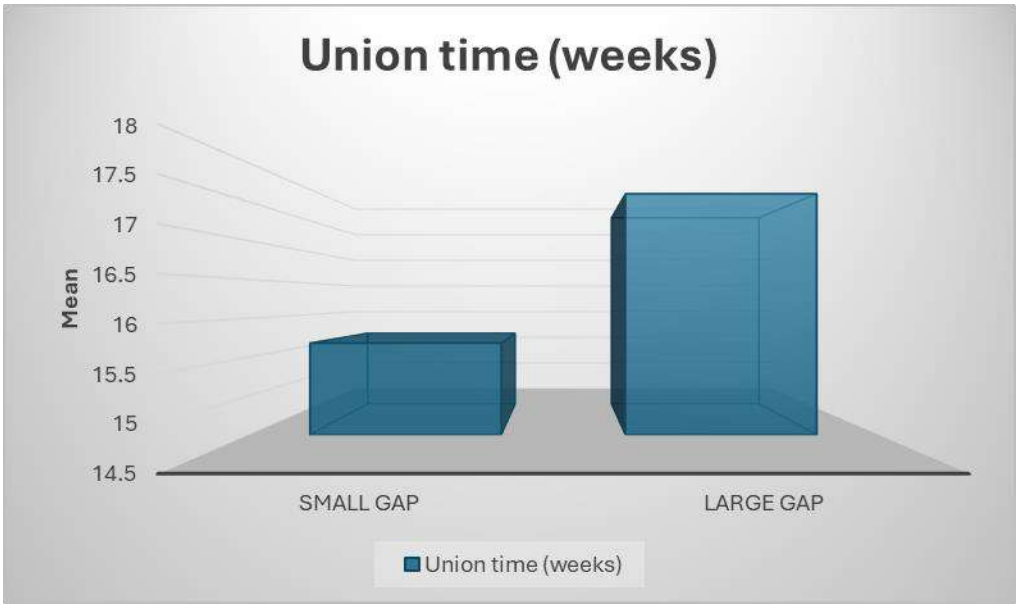

Figure 47: Comparison of union time among gaps categorized by Fragment displacement by the Lin method

Table 29: Comparison of fracture union rate according to Fragment's proximal displacement

Union	P1 (0–9 mm)	P2 (10-19 mm)	P3 (20-29 mm)	P4 (30-39 mm)	Total	Chi-Square	p-value
No (n %)	3 (6.25%)	8 (18.18%)	0 (0.0%)	0 (0.0%)	11 (10.37%)	5.38	0.146
Yes (n %)	45 (93.75%)	36 (81.82%)	9 (100%)	5 (100%)	95 (89.63%)		
Total (n %)	48 (100%)	44 (100%)	9 (100%)	5 (100%)	106 (100.0%)		

The table compares the union rate of participants in four groups (P1, P2, P3, P4) based on measurement ranges (0–9 mm, 10–19 mm, 20–29 mm, 30–39 mm), totalling 106 participants. In patient where union doesn't occurred, P1 had 3 (6.25%), P2 had 8 (18.18%), and P3 and P4 had none, totalling 11 (10.37%). In cases with union , P1 had 45 (93.75%), P2 had 36 (81.82%), and both P3 and P4 had 100%, totalling 95 (89.63%). The Chi-Square test resulted in a value of 5.38 with a p-value of 0.146, indicating no statistically significant differences in union status between the groups.

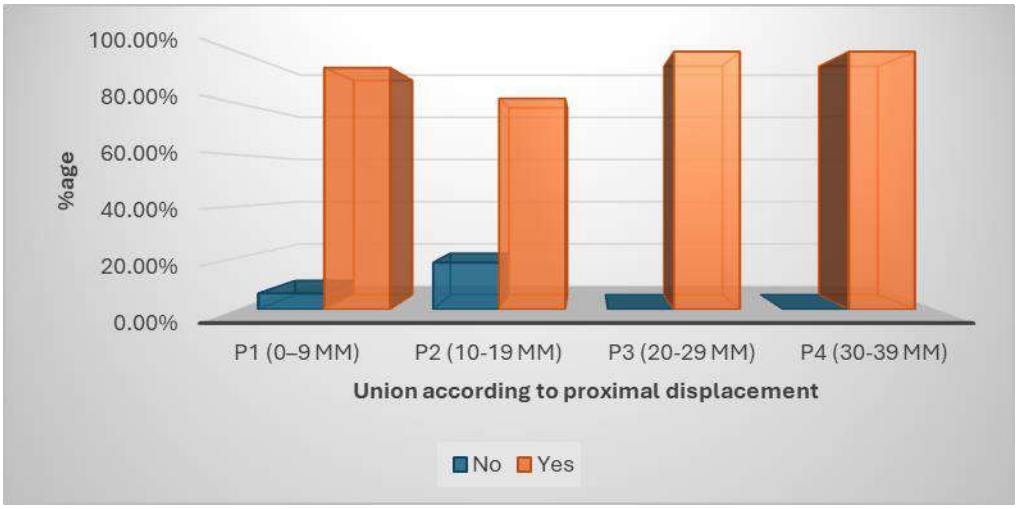

Figure 48: Comparison of fracture union rate according to Fragment's proximal displacement

Table 30: Comparison of fracture union time according to Fragment's proximal displacement

	P1 (N=45)	P2 (N=36)	P3 (N=9)	P4 (N=5)	Total (N=95)	F value	p-value
Mean ± SD(weeks)	15.42 ± 3.374	16.56 ± 2.853	16.67 ± 2.828	17.60 ± 2.191	16.08 ± 3.114	1.475	0.227

The table compares four groups (P1, P2, P3, P4) with sample sizes of 45, 36, 9, and 5, respectively, totalling 95 participants. The mean time for union (± SD) are: P1 = 15.42 ± 3.374, P2 = 16.56 ± 2.853, P3 = 16.67 ± 2.828, and P4 = 17.60 ± 2.191, with an overall mean of 16.08 ± 3.114. An ANOVA test yielded an F-value of 1.475 and a p-value of 0.227, indicating no statistically significant differences between the mean union time.

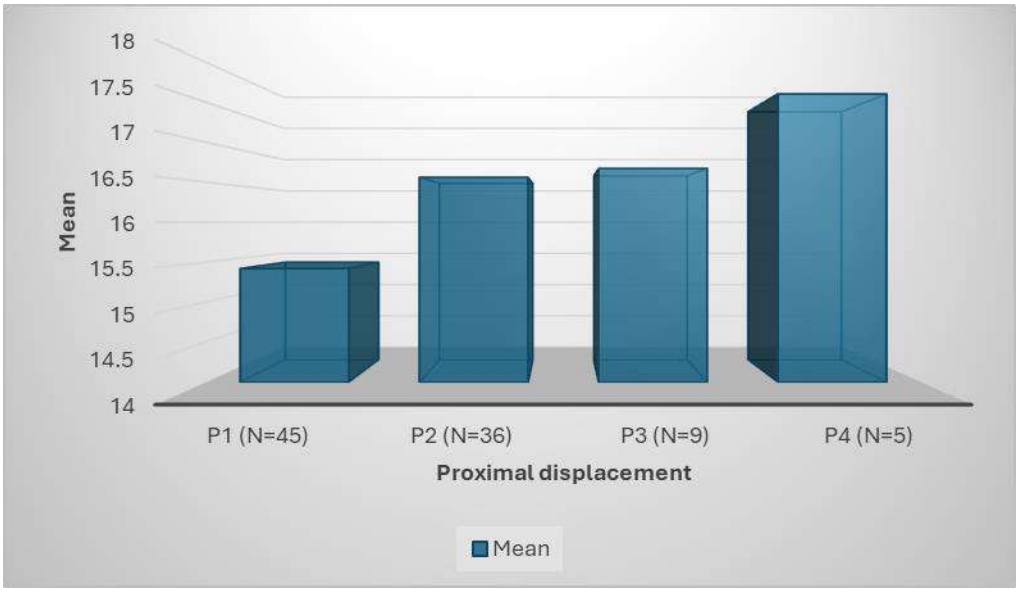

Figure 49: Comparison of fracture union time according to Fragment's proximal displacement

Table 31: Comparison of fracture union rate according to Fragment's Distal displacement

Union	D1 (0–9 mm)	D2 (10-19 mm)	D3 (20-29 mm)	D4 (30-39 mm)	Total	Chi-Square	p-value
No (n %)	3 (6.97%)	6 (13.95%)	1 (9.1%)	1 (11.11%)	11 (10.37%)	3.218	0.781
Yes (n %)	40 (93.03%)	37 (86.04%)	10 (90.9%)	8 (88.89%)	95 (89.63%)		
Total (n %)	43 (100%)	43 (100%)	11 (100%)	9 (100%)	106 (100.0%)		

For non-union, the percentages are: D1 = 6.97%, D2 = 13.95%, D3 = 9.1%, and D4 = 11.11%, with an overall rate of 10.37%. For union, the percentages are: D1 = 93.03%, D2 = 86.04%, D3 = 90.9%, and D4 = 88.89%, with an overall rate of 89.63%. the data was statistically non-significant.

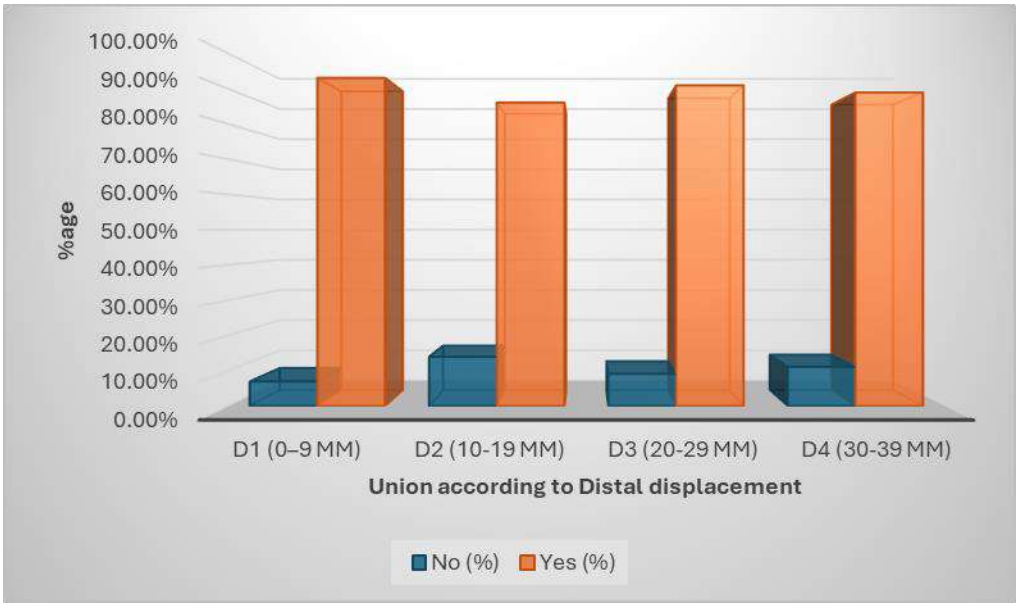

Figure 50: Comparison of fracture union rate according to Fragment's Distal displacement

Table 32: Comparison of fracture union time according to Fragment's Distal displacement

	D1 (N=40)	D2 (N=37)	D3 (N=10)	D4 (N=8)	Total (N=95)	F value	p-value
Mean ± SD(weeks)	15.25 ± 3.225	16.38 ± 2.822	17.20 ± 3.795	17.50 ± 2.070	16.08 ± 3.114	2.120	0.103

The mean value increases as the displacement category progresses from D1 to D4, suggesting a trend of higher measurement values with greater displacement. Specifically, D1 has the lowest mean value of 15.25, followed by D2 (16.38), D3 (17.20), and D4 (17.50), indicating a gradual increase. However, despite these apparent differences, the ANOVA test yielded an F-value of 2.120 and a p-value of 0.103. thus though there is an observable trend of increasing mean values with greater displacement, the statistical analysis suggests caution in interpreting these differences as significant across the groups studied.

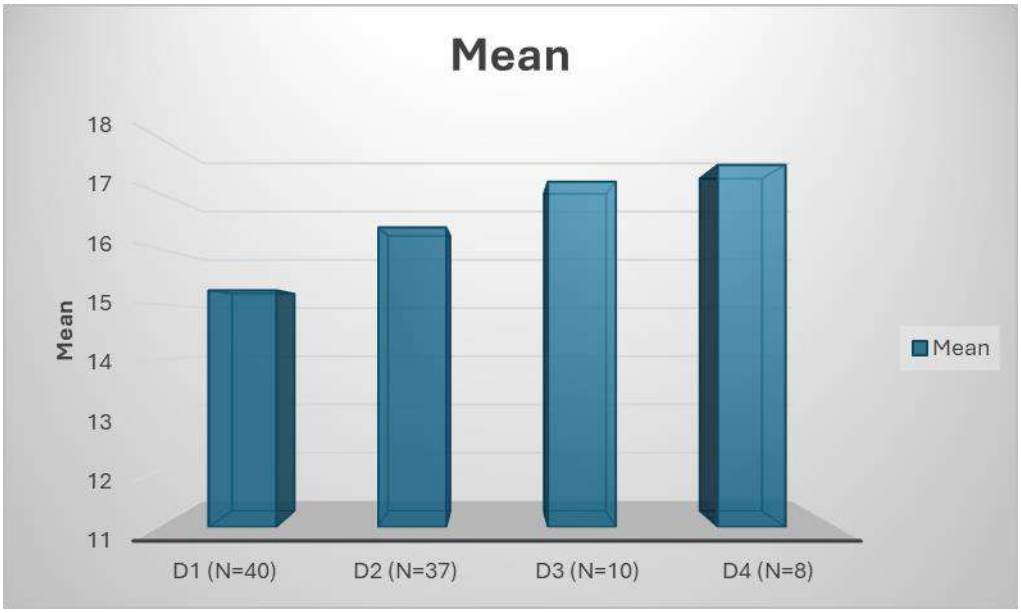

Figure 51: Comparison of fracture union time according to Fragment's Distal displacement

Functional outcome

Table 33: Association of knee function using Oxford knee score and type of implant used

Oxford knee score	AFN		DFN		Total		Chi-square	p-value
	n	%	n	%	n	%		
0-19 (severe knee dysfunction)	1	1.1%	1	6.7%	2	1.9%	2.181	0.536
20-29 (moderate to severe knee dysfunction)	7	7.7%	1	6.7%	8	7.5%		
30-39 (mild to moderate knee dysfunction)	24	26.4%	4	26.7%	28	26.4%		
40-48 (satisfactory knee function)	59	64.8%	9	60.0%	68	64.2%		
Total	91	100 %	15	100 %	106	100 %		

In terms of knee function, as measured by the Oxford Knee Score, both implant types show a range of scores. For severe knee dysfunction (score 0-19), only 1.1% of AFN cases and 6.7% of DFN cases fell in this category, with a total of 1.9%. For moderate to severe knee dysfunction (score 20-29), 7.7% of AFN and 6.7% of DFN cases scored in this range, summing up to 7.5% across both groups. The majority of patients scored in the satisfactory knee function range (score 40-48), with 64.8% of AFN cases and 60.0% of DFN cases, totaling 64.2%. The Chi-square test indicates no statistically significant difference between the implant types regarding knee function scores (p=0.536).

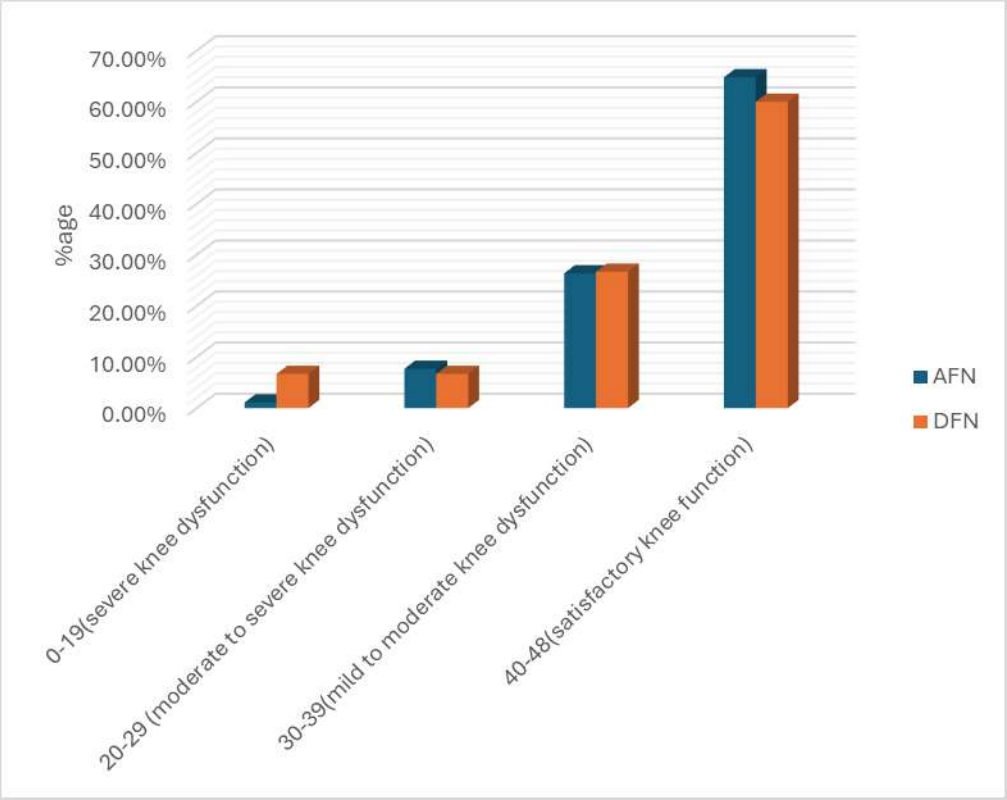

Figure 52: Association of knee function using Oxford knee score and type of implant used

Table 34: Association of Hip function using Modified Harris Hip score and type of implant used

Modified Harris Hip score	AFN		DFN		Total		Chi-square	p-value
	n	%	n	%	n	%		
<70: Poor result	2	2.2%	1	6.7%	3	2.8%	2.038	0.565
70–79: Fair result	10	11.0%	2	13.3%	12	11.3%		
80–89: Good result	32	35.2%	3	20.0%	35	33.0%		
≥90: Excellent result	47	51.6%	9	60.0%	56	52.8%		
Total	91	100%	15	100%	106	100%		

For Hip function, as measured by the Modified Harris Hip Score, results also appear similar across implant types. Poor results (score <70) were seen in 2.2% of AFN cases and 6.7% of DFN cases, totaling 2.8%. Fair results (score 70-79) occurred in 11.0% of AFN and 13.3% of DFN cases, totaling 11.3%. A majority scored “excellent” (≥90), with 51.6% in the AFN group and 60.0% in the DFN group, totaling 52.8%. Again, the Chi-square test found no significant difference in hip function outcomes between the implant types (p=0.565).

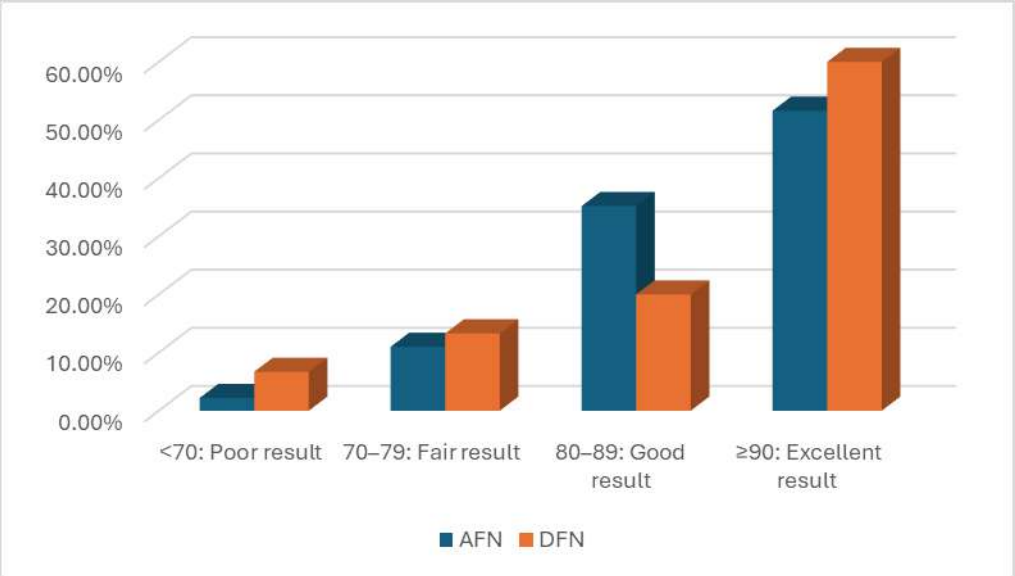

Figure 53: Association of Hip function using Modified Harris Hip score and type of implant used

Table 35: Distribution of patients according to Functional Outcomes at final follow up

Score	Outcomes	Frequency	Percent
oxford knee score	Satisfactory	68	64.2
	Mild to moderate	28	26.4
	Moderate to severe	8	7.5
	Severe	2	1.9
modified Harris Hip score	Excellent	56	52.8
	Good	35	33
	Fair	12	11.3
	Poor	3	2.8
VAS score	No pain	97	91.5
	Mild	8	7.5
	Moderate	1	0.9
	Severe	0	0
	Total	106	100

The table summarizes the distribution of scores for three different assessments: the Oxford knee score, the modified Hip Harris score, and the Visual Analog Scale (VAS) score, presenting the frequency and percentage of cases in each category.

For the Oxford knee score, a significant majority of patients, 64.2%, reported satisfactory knee function. An additional 26.4% experienced mild to moderate issues, while 7.5% had moderate to severe problems, and only 1.9% faced severe knee issues.

In terms of the modified Hip Harris score, 52.8% of patients were rated as excellent, and 33% were rated as good, indicating that a large majority of patients had favourable hip function outcomes. A smaller portion of patients, 11.3%, were rated as fair, and 2.8% were rated as poor, suggesting that while most patients had good to excellent outcomes, a few experienced suboptimal results.

Regarding pain levels measured by the VAS score, an overwhelming 91.5% of patients reported no pain, indicating effective pain management or minimal pain presence. A minor 7.5% experienced mild pain, and only 0.9% reported moderate pain.

Overall, the data indicate that the majority of patients have satisfactory knee and hip function with minimal pain, reflecting positive clinical outcomes across the assessed measures.

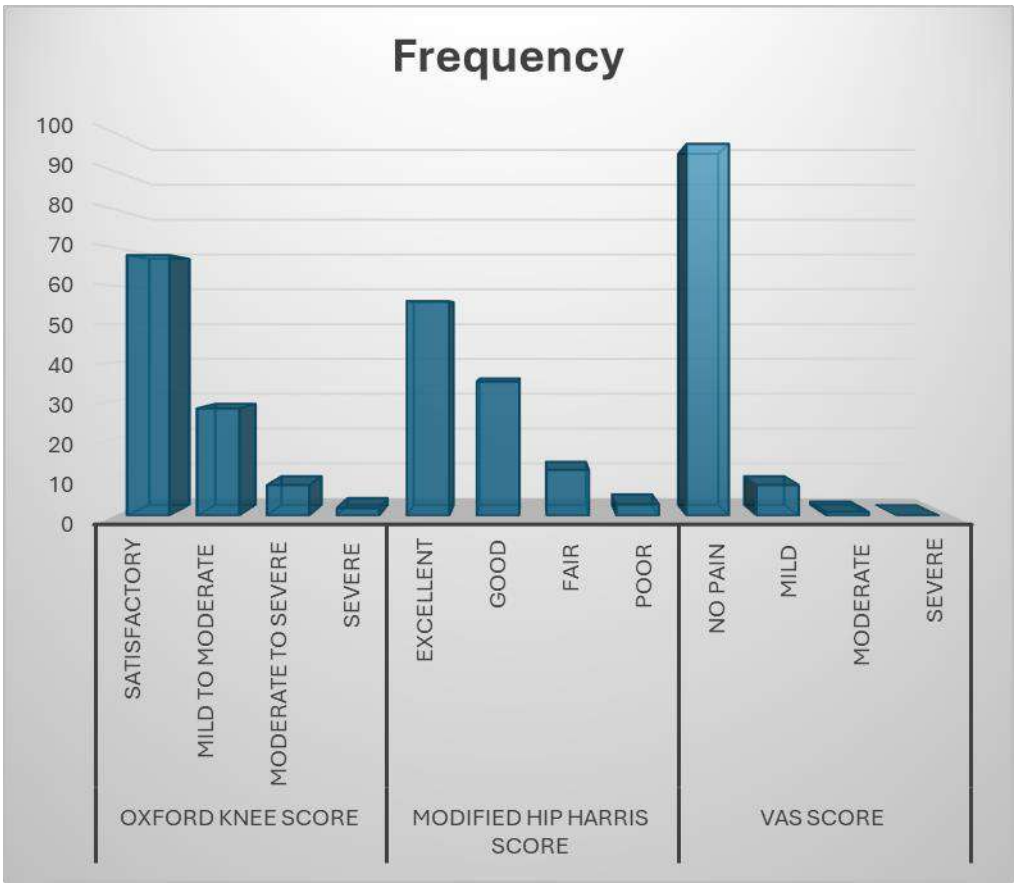

Figure 54: Distribution of patients according to Functional Outcomes at final follow up

Table 36: Distribution of patients according to complications

COMPLICATION	NUMBER OF CASES	%age
SUPERFICIAL INFECTION	7	6.60%
DEEP INFECTION	1	0.94%
MAL UNION	0	0.00%
DELAYED UNION	4	3.78%
NON-UNION	11	10.38%
IMPLANT FAILURE	2	1.89%

The most common complication reported was non-union, which occurred in 11 cases, representing 10.38% of the total. This was followed by superficial infections, observed in 7 cases or 6.60% of the total. Delayed union was noted in 4 cases, accounting for 3.78%, while implant failure was relatively rare, occurring in 2 cases or 1.89%. Deep infections were even less common, with only 1 case reported, making up 0.94% of the total. Notably, there were no cases of malunion. This distribution highlights non-union and superficial infections as the predominant complications in the study cohort, while other issues such as deep infections, delayed union, and implant failure were less frequent.

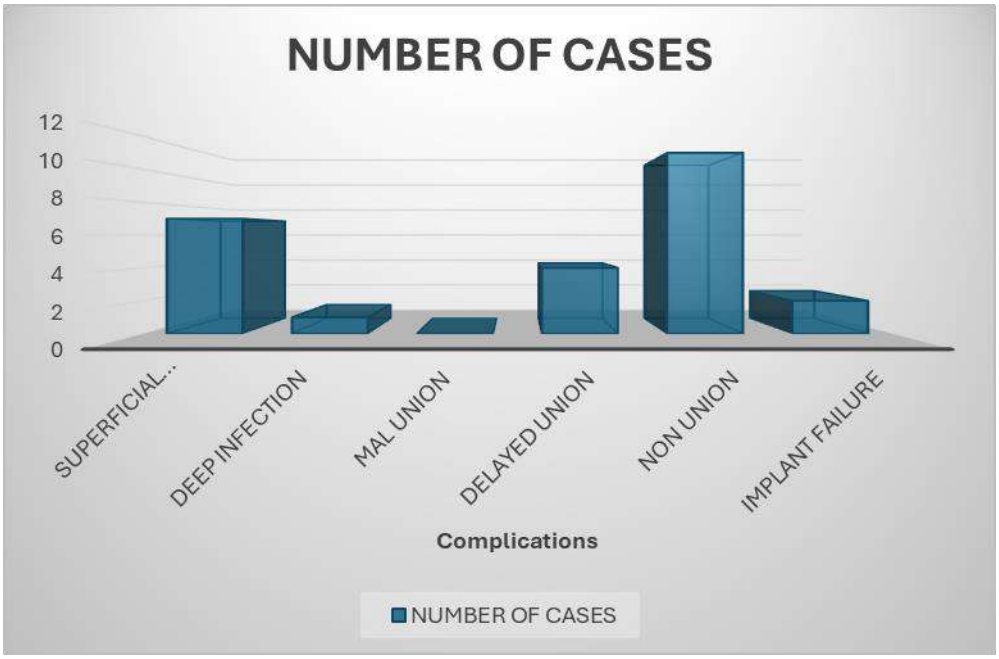

Figure 55: Distribution of patients according to complications

REOPERATE CASES

Table 37: Distribution of different procedures performed for complications

REASON	REOPERATE PROCEDURE DONE	NUMBER	Reoperate Rate
NON UNION	BONE GRAFTING	5	7.54%
	BONE GRAFTING WITH PLATING	2	
	EXCHANGE NAILING	1	
	DIDN'T OPT SURGERY	3	
DELAYED UNION	DYNAMISATION	2	1.80%
	DIDN'T OPT SURGERY	2	
SUPERFICIAL INFECTION	WOUND WASH	3	2.83%
	ASEPTIC DRESSING	4	
DEEP INFECTION	ANTIBIOTIC COATED NAIL	1	0.94%
IMPLANT FAILURE	SCREW REMOVAL	1	1.80%
	EXCHANGE NAIL	1	

Non-union was the most common reason for reoperation, with a total of 11 cases. Of these, 5 patients underwent bone grafting alone, 2 underwent bone grafting with plating, and 1 underwent exchange nailing. Three patients did not receive any surgery. The reoperation rate for non-union cases was 7.54%.

Delayed union resulted in 4 reoperation cases. Two patients received dynamization, while the other two did not undergo surgery. The reoperation rate for delayed union was 1.8%.

Superficial infections led to 3 reoperations. Wound wash procedures were performed in 3 cases, and rest 4 cases were managed with antiseptic dressings. The reoperation rate for superficial infections was 2.83%.

Deep infection prompted 1 reoperation case, where an antibiotic-coated nail was used. There were no cases requiring debridement and wound wash. The reoperation rate for deep infection was 0.94%.

Implant failure necessitated 2 reoperations. One patient had a screw removal, and another underwent an exchange nailing procedure. No patients in this category did not receive surgery. The reoperation rate for implant failure was 1.8%.

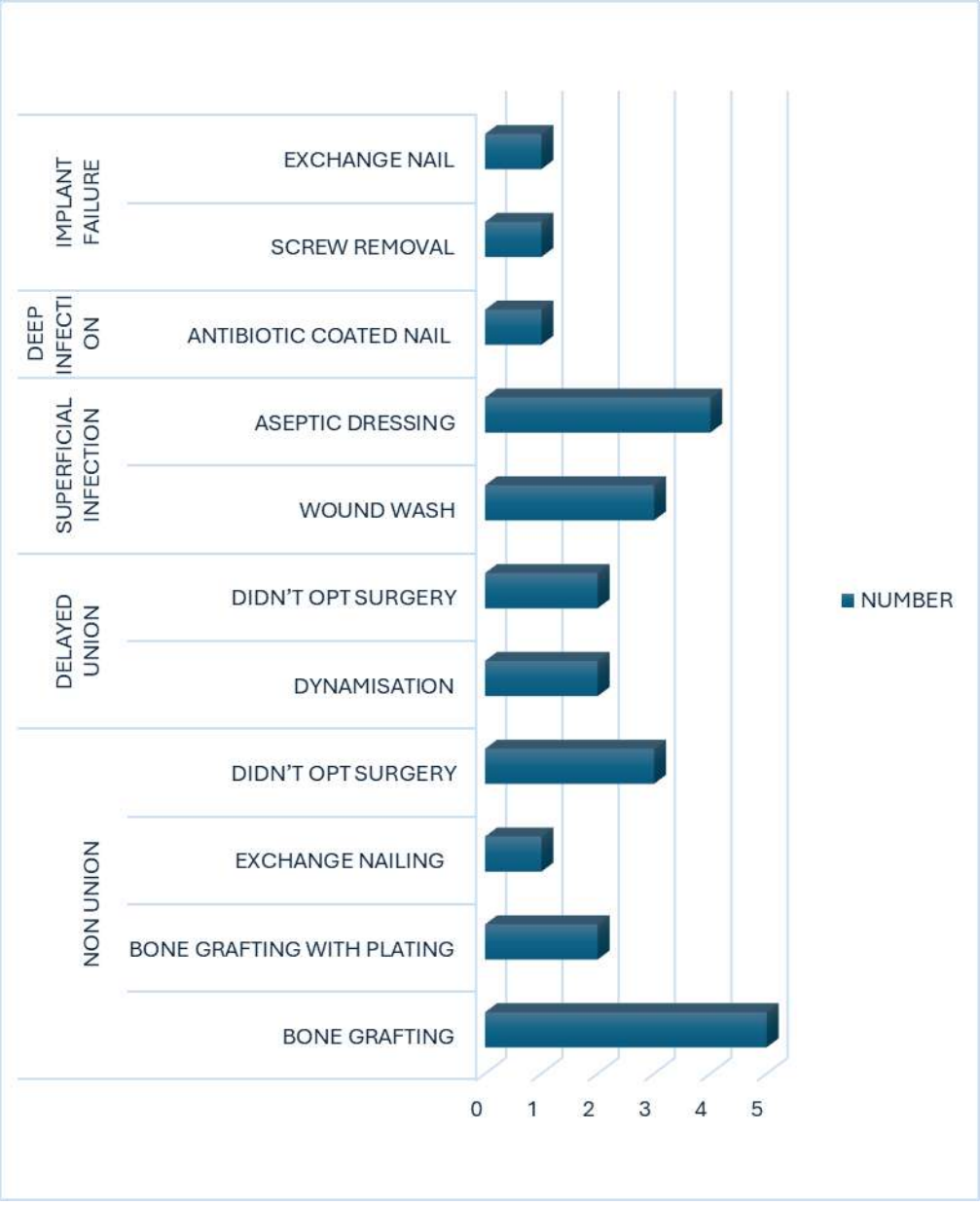

FIGURE 56: Distribution of different procedures performed for complications

DISCUSSION

The rise in Road traffic accidents (RTAs) has led to an increased incidence of high-velocity injuries, resulting in increase in the frequency of shaft femur fractures. Due to the high velocity nature of these injuries, the incidence of comminuted fractures has increased. Effective fixation is crucial for better outcomes, as the rate of non-union is high in case of such fractures. Various fixation modalities are available like internal fixation using different implants either via a closed approach with nailing or an open approach with plating to address these challenges. Out of all the treatment options intramedullary nailing has become a preferred treatment for femoral shaft fractures because it allows for closed reduction at the fracture site and better preserves blood circulation and causes minimum soft tissue damage which act as an important for femoral shaft fractures with large single fragments, which pose unique challenges for internal fixation.[2]

Salminen et al.[9] found that in cases of femoral shaft fractures, the occurrence of a third fragment was 10.5%, and nonunion occurred in 34% of these cases.

Four key factors affecting the healing of shaft fractures having a third fragment as identified by Vicenti et al were.[32]

- the size of the fragment
- the displacement of the fragment
- the angulation between the fragments and the shaft
- the fracture gap.

Of these, the size and displacement of the fragments were deemed most critical.

This study was done both retrospectively and prospectively to evaluate the effect of third fragment on the union of femoral shaft fractures managed with intramedullary nailing. We also studied functional

outcome and reoperation rates in fracture shaft femur with third fragment managed by intramedullary nailing.

Our study predominantly features patients in the 21-30 age group, accounting for 38.7% of the 106 participants, with a mean age of 32.28±13.22 years. When compared to other studies, notable differences and similarities emerge. For instance, Tsai et al.[39] reported an average patient age of 24.5 years, indicating a younger demographic than our study. Lee et al.[31] observed a mean age of 42.9 ± 18.6 years, which is significantly higher, pointing to an older cohort with a broader age range

In terms of gender distribution, the present study shows a significant male predominance, with 84.9% male patients and 15.1% female patients. This trend is consistent with findings from other studies by Yang et al. [40], Lee et al.[31], and Lin et al[8] who also highlighted male predominance in their studies.

A large proportion of the patients (94.3%) sustained their fractures from road traffic accidents (RSA), whereas a small fraction (5.7%) experienced fractures due to domestic falls. Yang et al. and Lee et al. also reported motor vehicle and car accidents (RSA) as the major cause of injury.

In our study, the majority of fractures occurred at the midshaft (50.9%), followed by the proximal shaft (32.1%) and distal shaft (17%). This distribution explains the prevalence of fractures across various sections of the femoral shaft. In comparison, Lin et al.[8] observed that around 20.83% of femoral shaft fractures were in the proximal segment, 64.58% in the middle segment, and 14.58% in the distal segment. Similarly, Tsai et al. [39] noted that about 23.75% of fractures were in the proximal segment, 63.75% in the middle segment, and 12.5% in the distal segment. Overall, all the studies recognize midshaft fractures as most common area of fracture.

In our study, based on the fracture morphology and location, two types of implants—antegrade femur nail (AFN) and distal femur nail (DFN)

were used for the treatment of fractures. Out of a total of 106 patients, AFN was used in 91 patients, while DFN was used in 15 patients.

In our study, we utilized the AO/OTA classification for femoral shaft fractures. The predominant category found was 32B, with 32B2 accounting for 61.3% patients and 32B3 for 18.9% patients, totaling 80.2% of all cases. In the 32C group, 32C2 category comprised of 5.7% patients and 32C3 of 14.2% patients, making up 19.8% cases collectively.

Fracture type

In terms of non-union rates, total nonunion in our study was 10.40% for shaft femur fractures treated with intramedullary nailing. If we look at previous studies like Wu et.al [47] have reported nonunion rate in shaft femur fracture as 9-10% which is comparable to our study. If seen individually according to OTA classification 8.20% of cases of fracture type 32B achieved nonunion, while 19% of fracture type 32C cases achieved the same outcome. Despite these differences, the data when statistically tested was insignificant (p value= 0.146) indicating that the likelihood of achieving union does not significantly differ between the two fracture types. The mean union time for fracture 32B was 16.1 weeks and for 32C was 16 weeks respectively.

In our study 95.4% of cases in 32B2 achieved union compared to 80% in 32B3. This suggests that the subtype of fracture within type 32B may influence the likelihood of successful union following treatment ($p<0.05$). When comparing the mean union times between 32B2 (Mean = 16.26 weeks) and 32B3 (Mean = 15.5 weeks), this data was statistically insignificant ($p = 0.4$). Fracture 32C was also examined. Among these, 5 out of 6 cases (83.3%) of 32C2 fractures and 12 out of 15 cases (81%) of 32C3 fractures achieved union, with mean union times of 15.2 weeks and 16.33 weeks, respectively. On comparison the p value was 0.146 indicating that the likelihood of achieving union following treatment is similar for both 32C2 and 32C3 fractures.

Fractures were compared based on their location: proximal, mid, and distal shaft femur, with respect to union rate and union time. Union was achieved in 47 out of 54 mid-shaft fractures (87%), 32 out of 34 proximal shaft fractures (94.1%), and 16 out of 18 distal shaft fractures (88.9%). The mean union times were 16.21 weeks for mid-shaft, 15.69 weeks for proximal shaft, and 16.50 weeks for distal shaft fractures. There was no statistically significant difference in union rates and union times across the different shaft segments.

In a study conducted by Yong-Gang Ma et al[48] found that incidence of nonunion in patients with closed distal shaft femur fracture undergoing interlocking intramedullary nailing was significant as compared to other fracture sites. In our study the comparison over union rate among different location of fracture was insignificant and union time required for fracture was not significantly related however distal shaft femur fractures required highest time for fracture union among all the fracture sites.

Fragment size

In the present study the data on third fragment fractures based on fragment size revealed distinct groupings among the 106 patients. Group A, comprising those with fragment sizes between 0-3.9 cm, constitutes the largest group at 44.3% (47 patients). Group B, with fragment sizes between 4-7.9 cm, includes 24.5% (26 patients) of the total. Group C, representing fragments 8 cm or larger, makes up 31.1% (33 patients) of total patients. Overall, this distribution provides a clear picture of the prevalence of different fragment sizes in third fragment fractures. In a study by Lee et al the distribution of fragment sizes in the study population is approximately 32.81% for Size A {0-3.9 cm}, 34.38% for Size B, and 32.81% for Size C.

In present study various parameters were studied with respect to the fragment size (A, B and C) and following findings were observed:

Group A (0-3.9 cm) had a mean proximal displacement of 12.84 mm, Group B (4-7.9 cm) had a mean proximal displacement of 12.37 mm,

and Group C (≥8 cm) had a mean proximal displacement of 13.02 mm. The f-value for the comparison is 0.04, and the p-value is 0.96. Regarding the distal displacement we observed that Group A, with the smallest fragments, had a mean distal displacement of 12.80 ± 9.79 mm. Group B showed a slightly higher mean distal displacement of 15.07 ± 14.45 mm. Group C, containing the largest fragments, exhibited the highest mean distal displacement at 16.33 ± 11.06 mm. however there was no statistically significant difference in proximal and distal displacement among the three groups. But it was observed that with increase in fragment size the distal displacement tends to increase. These results were consistent with the study done by Lee et al. [31] although in their study there was statistical difference present in distal displacement.

We observed that the number of patients in each group who did not achieve union was 2 (4.30%) in Group A, 3 (11.50%) in Group B, and 6 (18.20%) in Group C. Conversely, the number of patients who achieved union was 45 (95.70%) in Group A, 23 (88.50%) in Group B, and 27 (81.80%) in Group C. The total union rate across all groups was 89.60%. However, no significant difference was found in union rates among the different fragment size groups. The union rate was least in group C. Similar results were reported by the study conducted by Lee et al. where they found that union rate among group A was 90.5%, Group B was 81.8%, Group C, 15 was 71.4% respectively. However, their results were statistically significant for difference in fusion rates among the groups.

In the study by Tsai et al., [39] comparing union rates among different fragment sizes in the closed reduction group, they found a significantly higher non-union rate for fragments larger than 5.4 cm compared to those 5.4 cm or smaller. They proposed two hypotheses to explain this relationship between fragment size and non-union. Firstly, larger bony fragments may pose a greater risk of damaging the blood supply at the time of fracture due to the complex network of perforating branches from the deep femoral artery that encircle the femur. Secondly,

fractures involving larger fragments are more susceptible to instability and inadequate bony contact following closed reduction and intramedullary nailing, which can lead to non-union.

Additionally, larger fragments often result in larger fracture gaps, which can impede proper bony union. Luts et al. stressed the importance of reducing bone fragments to achieve smaller fracture gaps, thereby promoting optimal fracture healing. [49]

These findings underscore the critical role of fragment size and stability in the successful management and healing of femoral shaft fractures, particularly when considering closed reduction techniques

The term "Union time" denotes the mean duration required for the formation of bridging callus across fractured fragments. In our study, Group A fragments exhibited an average Union time of 15.24 ± 2.84 weeks. Conversely, Group B fragments had an average Union time of 16.70 weeks ± 2.87 weeks, while Group C fragments averaged 16.96 ± 3.48 weeks. Our research revealed a statistically significant variance in Union time across fragments of varying sizes, categorized into Group A, Group B, and Group C based on their axial lengths.

The study by lee et al. [31], showed increased union time as the fragment size increased among various groups. the results were statistically significant indicating that larger fracture fragments tend to have greater displacement, decreased union rates, and longer union times. This was similar to our study.

Fragment Displacement

J.R. Lee [31] method

Based on our measurements, proximal displacement was categorized as P1 to P4 based on specific ranges (0–9 mm, 10–19 mm, 20–29 mm, 30–39 mm), with a total of 106 participants. Among patients where union did not occur, 3 (6.25%) were in P1, 8 (18.18%) in P2, and none in P3 and P4, totaling 11 (10.37%). In cases where union occurred, 45 (93.75%) were in P1, 36 (81.82%) in P2, and 100% in both P3 and P4,

totaling 95 (89.63%). No statistically significant differences in union status between the groups was found. The mean time for union in weeks (± SD) were: P1 = 15.42 ± 3.374 weeks, P2 = 16.56 ± 2.853 weeks, P3 = 16.67 ± 2.828 weeks, and P4 = 17.60 ± 2.191 weeks, with an overall mean of 16.08 ± 3.114 weeks suggesting union time was more with more displacement, however results were not statistically significant.

For non-union in distal fragment displacement, the percentages were: D1 = 6.97% patients, D2 = 13.95% patients, D3 = 9.1% patients, and D4 = 11.11% patients, with an overall nonunion rate of 10.37%. For union, the percentages were: D1 = 93.03% patients, D2 = 86.04% patients, D3 = 90.9% patients, and D4 = 88.89% patients, with an overall union rate of 89.63%. However, the data was statistically nonsignificant.

As displacement category progresses from D1 to D4, there is a noticeable rise in the mean duration of union time, implying a correlation between higher displacement and longer union time. The mean values incrementally increase from 15.25 weeks for D1, to 16.38 weeks for D2, 17.20 weeks for D3, and 17.50 weeks for D4. Despite these apparent variations, the ANOVA test resulted in an F-value of 2.120 and a p-value of 0.103. This indicates that while there is a trend of increasing mean union times with greater displacement, but the data is not statistically significant.

Lee et al. [31] found a correlation between fracture displacement and union rates/times. At the proximal site, Group P1 had the highest union rate (89%) and shortest union time (12 ± 7.1 months), while Group P4 had a 0% union rate. At the distal site, Group D1 had the highest union rate (96%) and shortest union time (12 ± 6.6 months), with Groups D3 and D4 having 0% union rates. Greater displacement at both sites was linked to lower union rates and longer union times, highlighting the importance of considering fracture displacement in prognosis and treatment.

Lin method [8]

In the present study if the gap was >10 mm between the butterfly fragment and shaft were designated as the large-gap group and those with a gap =<10 mm as the small-gap group. We observed a total of 21 patients (19.8%) with large gap and 85(80.2%) with small gaps. When comparing the union rates and displacement sizes in the present study using the Lin method, the results indicate no significant difference between the small gap and large gap groups. Specifically, 11.8%(more patients) of the small gap group experienced non-union, compared to 4.8% of the large gap group. Conversely, 88.2% of the small gap group achieved union, compared to 95.2% (higher patients) of the large gap group. The overall union rate across both groups was 89.6%. However, the observed differences in union rates between small and large gap groups were not statistically significant (p-value 0.346).

In comparison, Lin et al. [8] observed significant differences in bone union rates based on the displacement size, with a marked disparity between groups. They found that fractures with more than 10 mm displacement had a substantially lower bone union rate (21.1%) compared to those with 10 mm or less displacement (75.9%).

Tsai et al [39] in their study showed that Non-union is more frequent in femoral shaft fractures with large third fragments and greater displacement during closed intramedullary nailing. While the present study aligns with Lin et al. [8] in observing trends related to displacement and union rates, it does not achieve statistical significance as Lin et al.'s [8] study did. This discrepancy may be attributed to differences in sample size, methodology, or other uncontrolled variables in the present study.

On comparing the fragment sizes for both the groups we observed that for Small Gap, the mean fragment size is 6.21 cm with a SD of 4.60 cm, while for Large Gap, the mean fragment size is 7.28 cm with a SD of 5.68 cm. A t-test for independent samples was conducted to assess

whether there is a statistically significant difference between the mean fragment sizes of these two groups.

The comparison of union times between small gap and large gap groups in our study revealed statistically significant differences. The mean union time for the small gap group was 15.68 ± 3.03 weeks, whereas the large gap group had a higher mean union time of 17.60 ± 3.02 weeks (p-value 0.01), indicating statistically significant difference in union times between the two groups, hence suggesting that large gap group requires significantly more time for union compared to the small gap group. This finding aligns with Lin et al., [8] who also observed longer union times associated with larger displacement sizes.

The prolonged union time in larger fragments may be due to the fact that the fracture's larger gap between fragments resulted in more interfragmentary motion due to poor cortical contact following intramedullary nailing. Excessive interfragmentary motion, whether axial or torsional, can lead to insufficient mineralized callus formation in the large-gap group.

Vincenti et al. [32] demonstrated in their study that the size of the third fragment (with a cutoff of 40 mm) is the primary factor influencing whether fracture healing occurs within six months or takes longer. Conversely, the mean displacement of the third fragment (with a cutoff of 12 mm) affects the likelihood of delayed healing rather than complete absence of healing.

Yang et al. [40] categorized third fragment displacement in femoral shaft fractures into four grades and assessed their impact on healing using the modified Radiological Union Scale for Femur (mRUSF). They found that Grade II (displacement >1/3 to <2/3 diameter) and III (displacement >2/3 diameter) displacements benefitted from closed reduction to minimize displacement and reduce non-union risk, while Grade IV (fragment turnover) fractures required precise reduction. The study highlighted the importance of managing displacement to optimize union rates and healing outcomes.

This information highlights the importance of fragment size and displacement in the management and prognosis of femoral shaft fractures, suggesting that minimizing displacement and ensuring stability are crucial for achieving successful union.

Functional Outcomes

The findings of this study reveal no significant differences in functional outcomes between patients who received Antegrade Femoral Nail (AFN) and those who received Distal Femoral Nail (DFN) implants, as assessed by the Oxford Knee Score and Modified Hip Harris Score ($p=0.536$). In terms of knee function, the Oxford Knee Score showed that the majority of patients in both implant groups achieved satisfactory scores (40-48), with 64.8% in the AFN group and 60.0% in the DFN group. Only a small percentage of patients fell within the severe or moderate-severe knee dysfunction categories.

Similarly, hip function as measured by the Modified Hip Harris Score demonstrated comparable outcomes across the two implant types. A majority of patients in both AFN (51.6%) and DFN (60.0%) groups achieved “excellent” scores (≥90), with only a small proportion of patients experiencing poor outcomes (<70). This study indicated no significant difference in hip function outcomes between AFN and DFN implants ($p=0.565$), suggesting that both implants perform similarly in terms of restoring hip function.

These findings suggest that, despite minor numerical differences, there is no substantial advantage of one implant type over the other in terms of knee or hip function. The choice of implant should be dictated by the fracture morphology and location. These results align with previous study done by Ostrum et al. [50] who reported equivalent outcomes with both antegrade and retrograde nailing techniques. Similarly, Daglar et al. [51] also concluded that knee function was comparable between antegrade and retrograde nailing when assessed by range of motion.

In conclusion, the results of this study suggest that AFN and DFN implants offer comparable functional outcomes in terms of knee and hip

function. This lack of significant difference aligns with the broader literature, indicating that both implants are effective options without clear superiority in functional performance. Therefore, implant selection may best be guided by individual patient factors, surgical expertise, and considerations such as potential pain outcomes, rather than expecting one implant to provide superior functional recovery over the other.

In the overall assessment of functional outcome at the 6-month follow-up, the Oxford Knee Score showed that a majority of patients (64.2%) achieved a "satisfactory" level of functional improvement, with 26.4% reported "mild to moderate" issues. Similarly, the modified Hip Harris Score revealed that over half of the patients (52.8%) attained an "excellent" outcome, and an additional 33% had "good" results.

Regarding pain levels measured by the VAS score, an overwhelming 91.5% of patients reported no pain, indicating effective pain management or minimal pain presence. A minor 7.5% experienced mild pain, and only 0.9% reported moderate pain. In their study of 30 cases, Sah et al. [52] demonstrated that all patients received a pain assessment using the Visual Analogue Scale (VAS) at each follow-up visit, which occurred at 6 weeks, 3 months, and 6 months. The average discrepancy between the groups, when comparing the time periods of 6 weeks and 3 months, was 0.567. This difference was found to be statistically significant. Like the study conducted by Ricci et al, [53] there was a significant reduction in pain observed at the 3-month and 6-month follow-up assessments. The average disparity between the groups when comparing the 3-month and 6-month periods was 0.267, and this difference was likewise statistically significant.

In comparison, the present study shows that 91.5% of patients reported no pain at all, which is a higher percentage compared to the findings of Sah et al. [52] and Ricci et al. [53] This indicates that the pain management strategies used in the present study were more effective. Additionally, the minor 7.5% of patients experiencing mild pain and the

0.9% reporting moderate pain further demonstrate the efficacy of the current approach

Overall, the data indicates that the majority of patients have satisfactory knee and hip function with minimal pain, reflecting positive clinical outcomes across the assessed measures.

We also studied the complications that leading to resurgery. It was observed that 11 patients had non-union, 7 patients had superficial infection, 4 patients had delayed union, 2 had implant failure and 1 patient had deep infection. These complications led to needs for resurgery for better functional as well as radiological outcome. Out of 11 non union patients 5 patient were treated with bone grafting, 2 patient had bone grafting along with plating, 1 patient was treated with exchange nailing and rest 3 patient denied for surgery. In case of 7 superficial infections, 3 patients underwent debridement and wound wash and rest 4 patients were managed with regular antiseptic dressing. In 4 patients of delayed union, dynamization of nail was done in 2 patients and rest 2 refused for surgery. In 2 cases of implant failure, 1 patient was operated with exchange nailing and other patient had broken screw removal.

Deep infection patient was treated with antibiotic coated nail insertion. in our study we found that that non-union was the most prevalent cause for reoperation, followed by superficial infection, while deep infection and implant failure are less frequent.

Reoperation rates were calculated, and it was observed that for different complications as in, nonunion, superficial infection, delayed union, implant failure, deep infection reoperation rates were 7.5%, 2.83%,1.8%, 1.8% and 0.94% respectively. Of 106 patients, 25 had complications in whom reoperation rate was 15.09%.

Our study on femoral shaft fractures treated with intramedullary nailing yielded several key insights. The patient cohort was predominantly young and male, with road traffic accidents being the primary cause of fractures, particularly in the midshaft region of the femur. Most fractures

were classified as type 32B(AO), with significant variations in fragment sizes impacting union rates and times. Notably, larger fragments, especially those over 8 cm were associated with higher non-union rates and longer union times. However, the study did not statistically find significant differences in union rates based on fragment displacement or gap sizes, despite observed trends.

Based on our study results, we conclude that increased comminution at the fracture site is associated with a higher likelihood of non-union. According to the location of the fracture site, the more proximal the fracture, the shorter the time required for union.

We also observed that as fragment size increased, the union rate decreased and union time increased. Additionally, increased fragment displacement from the shaft (either proximal or distal), results in longer union times. Similar results were obtained when the effect of fragment displacement on union time was evaluated using another method.

Our results suggest that routinely opening the fracture site for encerclage or manipulation of fragments to bring them closer to the shaft is not advisable, as it may negatively impact the union rate and increase union time. In cases involving large fragments, greater displacements, and extensive comminution; following intramedullary nailing, delayed bone union can be expected so it is prudent to monitor union progress and start weight bearing accordingly. patients should be advised to delay weight-bearing.

In conclusion, while intramedullary nailing remains an effective treatment for femoral shaft fractures with third fragments, several factors such as fragment size, displacement, and fracture subtype can significantly influence union rates and treatment outcomes. Further research with larger sample sizes and standardized methodologies could provide more definitive insights into optimizing treatment strategies for these complex fractures.

SUMMARY AND CONCLUSION

SUMMARY

Age Distribution: The majority of patients (38.7%) with third fragment fractures were in the 21-30 age group, followed by 23.6% in the 31-40 age group.

Gender Distribution: Males constituted a significant majority (84.9%) compared to females (15.1%) among patients with third fragment fractures.

Clinical History: Most fractures (94.3%) were due to road traffic accidents (RSA), while a smaller percentage (5.7%) resulted from domestic falls.

Laterality: Fractures were more common on the right side (68.9%) than the left side (31.1%).

Site of Fracture: The midshaft was the most common site (50.9%) for third fragment fractures, followed by the proximal shaft (32.1%) and distal shaft (17%).

Type of Implant Used: Two types of implants— AFN and DFN were used for the treatment of patients out of which 85.8% received AFN implant and the rest 14.2% received DFN implant.

AO/OTA Fracture Class: Type 32B fractures, particularly 32B2 (61.3%), were most prevalent, followed by 32B3 (18.9%).

Fragment Size and Displacement: Fragment sizes were categorized into three groups (0-3.9 cm, 4-7.9 cm, ≥8 cm). There was no significant association between fragment size and posterior or distal displacement, nor with proximal displacement.

Union Rates: The overall union rate across different fragment sizes (0-3.9 cm, 4-7.9 cm, ≥8 cm) was high (89.6%), with no significant difference observed based on fragment size.

Union Time: There was a statistically significant difference in union time among different fragment sizes ($p = 0.04$), with larger fragments (≥8 cm) requiring slightly longer union times.

Fragment Displacement and Union: Larger gaps (>10 mm) between the butterfly fragment and reduced shaft did not significantly affect union rates, but patients with larger gaps had significantly longer union times (17.60 weeks vs. 15.68 weeks, $p = 0.01$).

Fracture Type (32B vs 32C): There was no significant difference in union rates or union times between fracture types 32B and 32C. However, subtype analysis within 32B (32B2 vs 32B3) showed a significant difference in union rates ($p = 0.029$).

Functional Outcomes: The functional outcomes indicate that both AFN and DFN implants provide comparable results in femoral fracture management. At the 6-month follow-up, **64.8%** of patients in the AFN group and **60.0%** in the DFN group achieved satisfactory knee function, while **51.6%** of AFN patients and **60.0%** of DFN patients reached excellent hip function, as evidenced by high Oxford Knee and Modified Hip Harris scores. Pain levels were minimal, with **91.5%** of patients reporting no pain, suggesting effective pain control.

Reoperation Rates and Complications: Reoperations occurred in **15.09%** of patients, mainly due to non-union (**7.5%**), with other issues including superficial infections (**2.83%**), delayed union (**1.8%**), implant failure (**1.8%**), and deep infection (**0.94%**). Non-union was the most common reason for additional surgery, while infections and implant failures were less frequent but still notable.

CONCLUSION

The study investigated femoral shaft fractures treated with intramedullary nailing, focusing on the impact of third fragments on union, functional outcomes, and reoperation rates. It found that the majority of patients were young males with fractures primarily due to road traffic accidents, often located in the midshaft. Fractures were predominantly classified as type 32B, with a non-union rate of 10.40%. Union times were similar for fracture types 32B and 32C, though the subtype within 32B influenced union likelihood. Larger fragments (≥8 cm) and greater displacements were associated with higher non-union rates and longer union times, though differences in union rates based on fragment displacement and gap sizes were not statistically significant, but patients with larger gap had significantly longer union time. Overall, functional outcomes were similar for both AFN and DFN implants highlighting their similar efficacy in restoring knee and hip function with minimal pain, allowing implant selection to be based on individual patient and fracture characteristics rather than functional superiority. Complications such as non-union and infections led to a 15.09% reoperation rate. Managing large fragments and displacement is critical for optimal outcomes, and closer careful monitoring is necessary for complex cases. The study concludes that closed intramedullary nailing is effective method for managing femur shaft fractures with third fragment; however routine opening of fracture site to bring third fragment is not recommended.

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Cases

Case 1:

Pic. 1: Pre op X-rays AP and Lateral view

Pic. 2: Post operative AP and Lateral view

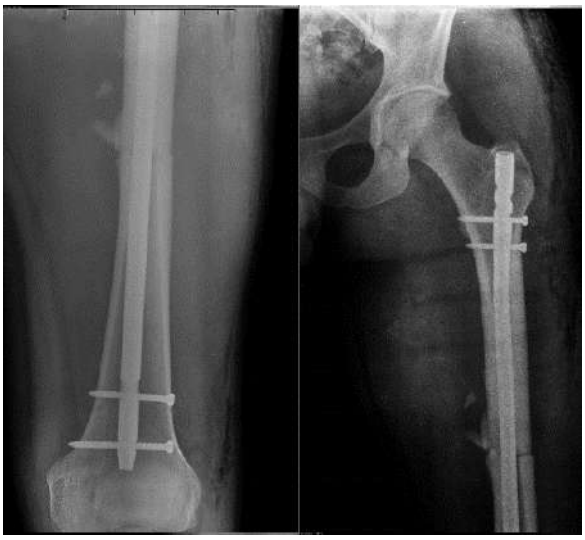
Pic. 3: Post op 2 month

Pic. 4:- Post op 4 month

Pic. 5: Post op 6 months

Case 2:

Pic. 6: pre op AP and Lateral X-rays



Pic. 7: Post operative X-rays

Pic. 8: Post op 1 month

Pic. 9: Post op 2 month

Pic. 10: Post op 3 month

Pic. 11: Union post op 4 month

Case 3:

Pic. 12: Pre op AP and Lateral X-rays

Pic. 13: Post op X-rays

Pic. 14: Post op 3 month

Pic. 15: Union Post op 5 month

Case 4:

Pic. 16: Pre op X-rays AP and Lateral

Pic. 17: Post op X-rays Ap and Lat.

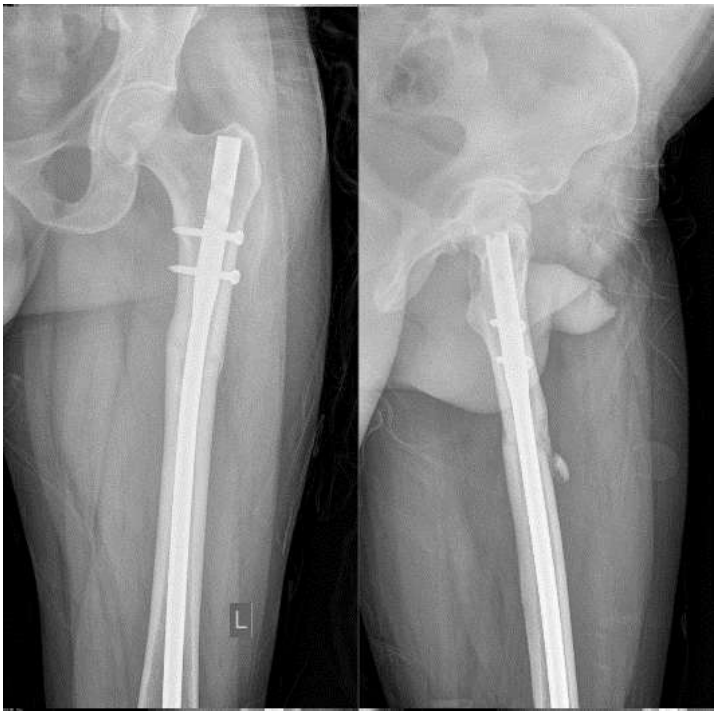
Pic. 18: Post op 2 month

Pic. 19: Post op 4 month

Case 5: Dynamisation

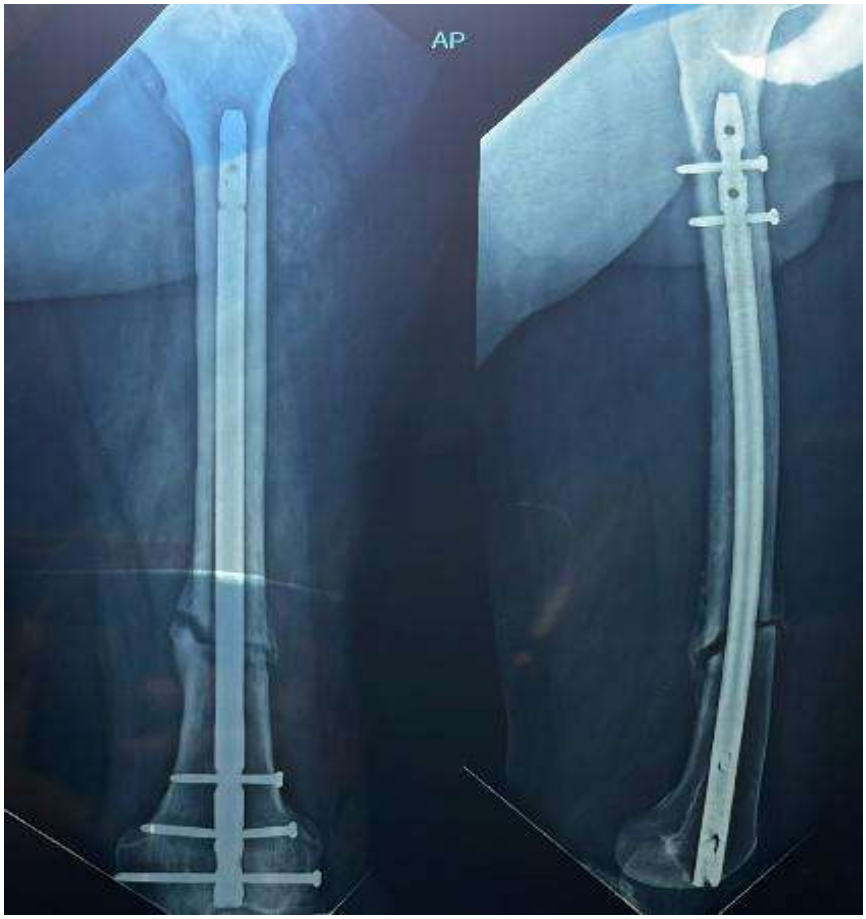
Pic. 20: Post op 4 month

Pic. 21: Post dynamization



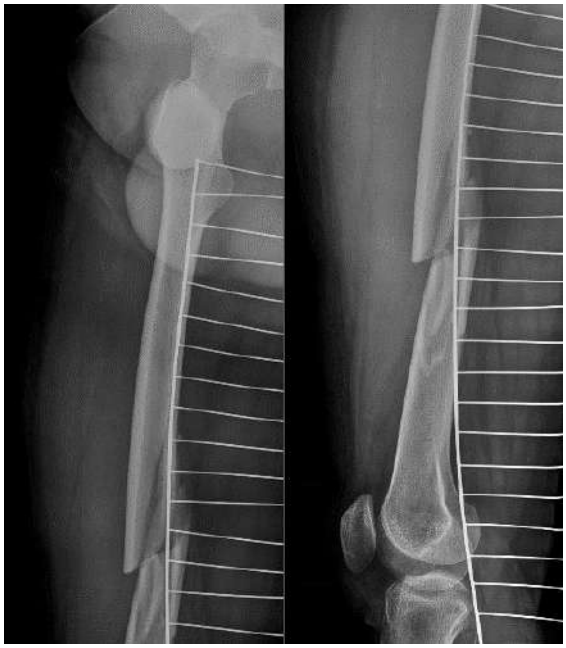
Pic. 22: Post 2 month dynamization

Case 6: Implant Failure:



Pic. 23: Post of 5 month Failed implant

Case 7: Non-union



Pic. 24: Pre op AP and Lateral X-rays

Pic. 25: Post op X-rays

Pic. 26: Non union post op 6 month

Pic. 27: post bone grafting and plating for non- union

S.No	Name	Age	Sex	MRD	D.O.A	D.O.S	Clinical history	Fracture Characteristics			Implant Used	
								Side affected	Site of fracture	AO/OTA Fracture Class		Fragment Size(group)
1	JS	31	Male	1272734	21-03-2022	22-03-2022	RSA	RIGHT	DISTAL SHAFT	32B2	DFN	1.9(A)
2	PB	50	Female	1285455	10-04-2022	10-04-2022	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	2.35(A)
3	AA	20	MALE	1281479	03-04-2022	14-04-2022	RSA	RIGHT	PROXIMAL SHAFT	32B3	AFN	1.39(A)
4	AA	20	MALE	1281479	03-04-2022	14-04-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	2.26(A)
5	JS	25	MALE	1291797	22-04-2022	23-04-2022	RSA	LEFT	DISTAL SHAFT	32B2	DFN	1.73(A)
6	KJ	57	FEMALE	1304190	14-05-2022	17-05-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	3.83(A)
7	GS	32	MALE	1307680	20-05-2022	20-05-2022	RSA	RIGHT	DISTAL SHAFT	32B3	AFN	3.43(A)
8	AS	18	MALE	1313244	29-05-2022	31-05-2022	RSA	RIGHT	DISTAL SHAFT	32B2	AFN	1.76(A)
9	MS	23	MALE	1335301	04-07-2022	05-07-2022	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	2.92(A)
10	N	20	FEMALE	1337252	08-07-2022	08-07-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	7.74(B)
11	HS	33	MALE	1347158	24-07-2022	26-07-2022	DOMESTIC FALL	RIGHT	MID SHAFT	32B2	AFN	4.46(B)
12	HS	25	MALE	1378429	12-09-2022	15-09-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	0.96(A)
13	HS	18	MALE	1388495	28-10-2022	01-10-2022	RSA	LEFT	MID SHAFT	32B2	AFN	5.21(B)
14	BB	28	MALE	1393751	07-10-2022	08-10-2022	DF	RIGHT	PROXIMAL SHAFT	32C3	AFN	14.3(C)
15	JS	22	MALE	1408316	03-11-2022	04-11-2022	RSA	LEFT	MID SHAFT	32B3	AFN	5.44(B)
16	JS	34	MALE	1409037	05-11-2022	05-11-2022	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	12.8(C)
17	SS	60	MALE	1408351	03-11-2022	06-11-2022	RSA	RIGHT	PROXIMAL SHAFT	32C2	AFN	11.7(C)
18	DS	18	MALE	1417730	20-11-2022	21-11-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	6.3(B)
19	AS	27	MALE	1418544	21-11-2022	22-11-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	12.13(C)
20	SK	27	MALE	1419875	24-11-2022	24-11-2022	RSA	LEFT	PROXIMAL SHAFT	32B3	AFN	15.73(C)
21	KS	25	MALE	1420428	24-11-2022	25-11-2022	RSA	LEFT	MID SHAFT	32B2	AFN	2.83(A)
22	TA	18	MALE	1422664	29-11-2022	06-12-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	0.63(A)
23	RK	47	MALE	371252	11-01-2023	12-01-2023	RSA	LEFT	PROXIMAL SHAFT	32B3	AFN	8.57(C)
24	RKA	44	MALE	1457389	06-02-2023	10-02-2023	RSA	RIGHT	MID SHAFT	32B2	AFN	2.1(A)
25	JK	60	FEMALE	1466873	20-02-2023	24-02-2023	RSA	RIGHT	DISTAL SHAFT	32B2	DFN	2.06(A)
26	GS	26	MALE	1472737	01-03-2023	02-03-2023	RSA	LEFT	MID SHAFT	32C3	AFN	6.14(B)
27	SS	18	MALE	1484645	21-03-2023	21-03-2023	RSA	RIGHT	MID SHAFT	32B2	AFN	7.9(B)
28	TS	30	MALE	1491102	01-04-2023	01-04-2023	RSA	RIGHT	MID SHAFT	32B3	DFN	5.08(B)
29	JG	36	MALE	1498304	12-04-2023	12-04-2023	RSA	RIGHT	MID SHAFT	32B3	AFN	2.95(A)
30	GS	40	MALE	1500728	17-04-2023	18-04-2023	RSA	LEFT	MID SHAFT	32C3	AFN	11.08(C)
31	MS	28	MALE	1526793	31-05-2023	31-05-2023	RSA	RIGHT	MID SHAFT	32C3	AFN	8.87(C)
32	B	49	FEMALE	1533826	11-06-2023	12-06-2023	DF	RIGHT	PROXIMAL SHAFT	32B2	AFN	9.34(C)
33	GR	18	MALE	1541573	24-06-2023	27-06-2023	RSA	RIGHT	MID SHAFT	32C2	AFN	3.37(A)
34	PN	42	MALE	1531684	07-06-2023	19-06-2023	RSA	RIGHT	MID SHAFT	32C3	AFN	7.66(B)
35	JK	19	MALE	1546405	04-07-2023	04-07-2023	RSA	RIGHT	MID SHAFT	32B2	AFN	2.68(A)
36	RK	25	MALE	1565344	05-08-2023	07-08-2023	RSA	LEFT	MID SHAFT	32B2	AFN	2.04(A)
37	MS	26	MALE	1579636	28-08-2023	29-08-2023	RSA	RIGHT	PROXIMAL SHAFT	32B3	AFN	10.2(C)
38	S	34	FEMALE	1591487	18-09-2023	18-09-2023	RSA	RIGHT	MID SHAFT	32B2	AFN	8.69(C)
39	JS	31	MALE	962254	04-09-2020	05-09-2020	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	3.94(A)
40	GS	38	MALE	965252	13-09-2020	13-09-2020	RSA	RIGHT	PROXIMAL SHAFT	32C3	AFN	20.6(C)
41	RS	38	MALE	969459	25-09-2020	29-09-2020	RSA	RIGHT	MID SHAFT	32B2	AFN	2.08(A)
42	CS	48	MALE	972634	06-10-2020	06-10-2020	RSA	RIGHT	MIDSHAFT	32B3	AFN	6.24(B)
43	APK	22	FEMALE	975573	14-10-2020	19-10-2020	RSA	RIGHT	MID SHAFT	32B3	AFN	11(C)
44	MS	59	MALE	977761	19-10-2020	22-10-2020	RSA	RIGHT	DISTAL SHAFT	32B2	AFN	1.63(A)
45	GS	38	MALE	981071	28-10-2020	29-10-2020	RSA	LEFT	MID SHAFT	32C3	AFN	11.3(C)
46	NS	53	FEMALE	982842	03-11-2020	03-11-2020	RSA	RIGHT	MID SHAFT	32B3	AFN	13.76(C)
47	NS	51	MALE	985319	09-11-2020	10-11-2020	RSA	RIGHT	DISTAL SHAFT	32B2	DFN	5.14(B)
48	GK	59	FEMALE	987803	17-11-2020	22-11-2020	RSA	RIGHT	MID SHAFT	32B2	AFN	7.32(B)
49	GS	28	MALE	1003577	22-12-2020	23-12-2020	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	18.48(C)
50	JS	31	MALE	1005355	26-12-2020	27-12-2020	RSA	LEFT	MID SHAFT	32B2	AFN	7.94(B)
51	HS	19	MALE	1018382	27-01-2020	27-01-2020	RSA	LEFT	MID SHAFT	32B2	AFN	1.7(A)
52	RS	53	MALE	1028744	15-02-2021	16-02-2021	RSA	RIGHT	MID SHAFT	32C2	DFN	1.69(A)
53	GS	51	MALE	1045307	08-03-2021	09-03-2021	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	10.24(C)

S.No	Third Fragment			Post Operative Management		Time of Fracture Union	
	Proximal Displacment(group)	Distal displacement(group)	Displacement using Lin method	Time of partial weight bearing(weeks)	time of full weight bearing(weeks)	Union(yes/no)	Union time(weeks)
1	4.8(P1)	7.2(D1)	SMALL GAP	4	12	YES	16
2	7.7(P1)	6.8(D1)	SMALL GAP	16	24	YES	20
3	22.5(P3)	16.3(D2)	LARGE GAP	22	26	YES	20
4	10.4(P2)	10.4(D2)	SMALL GAP	22	26	YES	16
5	31.1(P4)	37.5(D4)	LARGE GAP	12	22	YES	20
6	10(P2)	20.7(D3)	SMALL GAP	16	24	YES	16
7	8.7(P1)	6.1(D1)	SMALL GAP	8	15	YES	16
8	34.5(P4)	32.8(D4)	LARGE GAP	4	12	YES	16
9	23.4(P3)	12.4(D2)	SMALL GAP	12	20	YES	14
10	10.3(P2)	13.3(D2)	SMALL GAP	4	16	YES	16
11	11.4(P2)	8.7(D1)	SMALL GAP	10	18	YES	16
12	6.2(P1)	3.1(D1)	SMALL GAP	4	12	YES	12
13	6.6(P1)	12.7(D2)	SMALL GAP	6	12	YES	16
14	6(P1)	6.6(D1)	SMALL GAP	4	12	YES	12
15	8.7(P1)	8.2(D1)	SMALL GAP	4	12	YES	12
16	5.6(P1)	11.7(D2)	SMALL GAP	4	12	YES	16
17	16.6(P2)	14.9 (D2)	SMALL GAP	8	20	YES	16
18	25.2(P3)	46.8(D4)	LARGE GAP	4	12	YES	16
19	18.3(P2)	24.7(D3)	LARGE GAP	6	16	YES	16
20	13.5(P2)	6.6(D1)	SMALL GAP	4	10	YES	14
21	5.1(P1)	5.1(D1)	SMALL GAP	4	12	YES	16
22	20.5(P3)	19.7(D2)	LARGE GAP	12	22	YES	16
23	5.6(P1)	19.4(D2)	SMALL GAP	12	26	NO	NO
24	9.9(P1)	6.6(D1)	SMALL GAP	4	12	YES	12
25	53.6(P4)	54.8(D4)	LARGE GAP	8	16	YES	16
26	7.1(P1)	5.6(D1)	SMALL GAP	8	20	NO	NO
27	13.2(P2)	17.1(D2)	SMALL GAP	10	18	YES	16
28	14.9(P2)	9.8(D1)	SMALL GAP	8	16	NO	NO
29	11.2(P2)	22.4(D3)	SMALL GAP	12	20	YES	16
30	6.7(P1)	5.1(D1)	SMALL GAP	16	20	YES	16
31	17.5(P2)	10.9(D2)	SMALL GAP	12	NO	NO	NO
32	9.2(P1)	20.2(D3)	SMALL GAP	32	NO	NO	NO
33	19.2(P2)	25.4(D3)	LARGE GAP	8	16	YES	12
34	14.5(P2)	14.5(D2)	SMALL GAP	8	20	YES	16
35	15.3(P2)	25(D3)	LARGE GAP	8	16	YES	16
36	16.6(P2)	10.5(D2)	SMALL GAP	4	10	YES	16
37	11.2(P2)	13.8(D2)	SMALL GAP	8	16	YES	16
38	17.6(P2)	37.3(D4)	LARGE GAP	8	20	NO	NO
39	10.1(P2)	7.3(D1)	SMALL GAP	8	16	YES	14
40	13.6(P2)	30.4(D4)	LARGE GAP	6	14	YES	20
41	14.7(P2)	9(D1)	SMALL GAP	4	12	YES	16
42	9(P1)	59.3(D4)	LARGE GAP	12	22	YES	16
43	27(P3)	18.9(D2)	LARGE GAP	6	14	YES	20
44	1.1(P1)	8.1(D1)	SMALL GAP	8	16	YES	16
45	19.9(P2)	13.2(D2)	SMALL GAP	6	34	NO	NO
46	6.2(P1)	3.4(D1)	SMALL GAP	4	12	YES	16
47	6(P1)	3.6(D1)	SMALL GAP	8	20	YES	16
48	1.5(P1)	21.5(D3)	SMALL GAP	20	26	YES	20
49	9(P1)	13.1(D2)	SMALL GAP	6	14	YES	16
50	10.6(P2)	10.2(D2)	SMALL GAP	6	14	YES	16
51	2.7(P1)	4.4(D1)	SMALL GAP	4	12	YES	12
52	12.8(P2)	6(D1)	SMALL GAP	8	14	NO	NO
53	10.7(P2)	9.3(D1)	SMALL GAP	4	12	YES	16

S.No	Final Hip ROM	Final Knee ROM	Pain (/10)	mHHS	OKS	Incidence of Complications					
			Final followup	Final followup	Final followup	Infection	Delayed union	Malunion	Non-union	Implant Failure	Resurgery
1	FLX 110, EXT 10	0-125	0	92	45	NO	NO	NO	NO	NO	NO
2	FLX 90, EXT 5	0-95	0	79	29	NO	NO	NO	NO	NO	NO
3	FLX 110, EXT 10	0-130	0	92	44	NO	NO	NO	NO	NO	NO
4	FLX 108, EXT 8	0-125	0	88	42	NO	NO	NO	NO	NO	NO
5	FLX 100, EXT 15	0-130	0	92	42	NO	NO	NO	NO	NO	NO
6	FLX 90, EXT 10	0-100	0	86	38	NO	NO	NO	NO	NO	NO
7	FLX 100, EXT 15	0-80	0	88	28	NO	NO	NO	NO	NO	NO
8	FLX 90, EXT 10	0-130	0	84	44	YES(ABCESS SUTURE)	NO	NO	NO	NO	NO
9	FLX 100, EXT 15	0-90	0	88	36	NO	NO	NO	NO	NO	NO
10	FLX 110, EXT 15	0-100	0	92	42	NO	NO	NO	NO	NO	NO
11	FLX 90, EXT 10	0-100	0	79	38	NO	NO	NO	NO	NO	NO
12	FLX 100, EXT 15	0-100	0	92	42	NO	NO	NO	NO	NO	NO
13	FLX 100,EXT 10	0-95	0	86	36	NO	NO	NO	NO	NO	NO
14	FLX 104, EXT 6	0-110	0	88	40	NO	NO	NO	NO	NO	NO
15	FLX 114,EXT 10	0-124	0	94	44	NO	NO	NO	NO	NO	NO
16	FLX 100, EXT 15	0-130	0	92	44	NO	NO	NO	NO	NO	NO
17	FLX 110, EXT 10	0-125	0	94	44	NO	NO	NO	NO	NO	NO
18	FLX 112, EXT 14	0-124	0	94	46	NO	NO	NO	NO	NO	NO
19	FLX 110, EXT 15	0-130	0	92	44	NO	NO	NO	NO	NO	NO
20	FLX 115, EXT 20	0-135	0	95	44	NO	NO	NO	NO	NO	NO
21	FLX 112, EXT 18	0-132	0	94	44	NO	NO	NO	NO	NO	NO
22	FLX 90, EXT 10	0-110	0	88	40	YES(SUTURE ABCESS)	NO	NO	NO	NO	YES(WOUND WASH)
23	FLX 100, EXT 10	0-125	1	90	40	NO	NO	NO	YES	NO	YES(BONE GRAFTING OCT 2023)
24	FLX 80, EXT 4	0-90	1	78	29	NO	NO	NO	NO	NO	NO
25	FLX 100, EXT 8	0-110	0	87	39	NO	NO	NO	NO	NO	NO
26	FLX 80, EXT 5	0-70	0	68	24	YES(SUTURE ABCESS)	NO	NO	NO	YES	YES
27	FLX 110, EXT 15	0-120	0	92	42	NO	NO	NO	NO	NO	NO
28	FLX 90, EXT 5	0-90	1	76	32	NO	NO	NO	YES	NO	YES(BONE GRAFTING AUG, 2023)
29	FLX 110, EXT 15	0-110	0	90	42	NO	NO	NO	NO	NO	NO
30	FLX 90, EXT 10	0-90	0	75	29	NO	NO	NO	NO	NO	NO
31	FLX 92, EXT 5	0-90	1	70	28	NO	NO	NO	YES	NO	YES(BONE GRAFTING OCT 2023)
32	FLX 0-80, EXT 4	0-80	1	76	32	NO	NO	NO	YES	NO	YES(BONE GRAFTING 5/24)
33	FLX 110, EXT 10	0-120	0	90	44	NO	NO	NO	NO	NO	NO
34	FLX 100, EXT 15	0-100	0	88	38	NO	NO	NO	NO	NO	NO
35	FLX 110, EXT 10	0-120	0	90	38	NO	NO	NO	NO	NO	NO
36	FLX 110, EXT 15	0-130	0	92	44	NO	NO	NO	NO	NO	NO
37	FLX 100, EXT 5	0-130	0	86	45	NO	NO	NO	NO	NO	NO
38	FLX 95, EXT 5	0-110	0	72	30	NO	NO	NO	YES	NO	NO
39	FLX 110, EXT 15	0-125	0	90	42	NO	NO	NO	NO	NO	NO
40	FLX 100, EXT5	0-130	0	88	44	YES(SUTURE ABCESS)	NO	NO	NO	NO	YES(WOUND WASH)
41	FLX 110, EXT 15	0-130	0	94	44	NO	NO	NO	NO	NO	NO
42	FLX 105, EXT 5	0-125	0	88	38	NO	NO	NO	NO	NO	NO
43	FLX 104, EXT 10	0-120	0	90	38	NO	NO	NO	NO	NO	NO
44	FLX 95, EXT 5	0-100	0	75	36	NO	NO	NO	NO	NO	NO
45	FLX 80, EXT 5	0-70	0	69	19	NO	NO	NO	YES	YES	YES
46	FLX 110, EXT 15	0-125	0	89	42	NO	NO	NO	NO	NO	NO
47	FLX 110, EXT 15	0-130	0	92	42	NO	NO	NO	NO	NO	NO
48	FLX 110, EXT 10	0-125	0	85	40	NO	NO	NO	NO	NO	NO
49	FLX 112, EXT 10	0-124	0	92	42	NO	NO	NO	NO	NO	NO
50	FLX 110, EXT 5	0-125	0	84	37	NO	NO	NO	NO	NO	NO
51	FLX 115, EXT 12	0-130	0	94	44	NO	NO	NO	NO	NO	NO
52	FLX 110, EXT 15	0-60	1	68	19	YES	NO	NO	YES	NO	NO
53	FLX 110, EXT 10	0-120	0	90	38	NO	NO	NO	NO	NO	NO

S.No	Name	Age	Sex	MRD	D.O.A	D.O.S	Clinical history	Fracture Characteristics			Implant Used	
								Side affected	Site of fracture	AO/OTA Fracture Class		Fragment Size(group)
54	ASG	26	MALE	1091494	21-04-2021	21-04-2021	RSA	LEFT	MID SHAFT	32B2	AFN	2.79(A)
55	SD	35	MALE	1110942	19-05-2021	20-05-2021	RSA	LEFT	MID SHAFT	32B2	AFN	8.4(C)
56	PS	29	MALE	1113339	25-05-2021	27-05-2021	RSA	RIGHT	MID SHAFT	32C2	AFN	7.52(B)
57	GS	27	MALE	1114123	27-05-2021	28-05-2021	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	5.74(B)
58	SV	37	MALE	1119046	07-06-2021	07-06-2021	RSA	RIGHT	MID SHAFT	32B2	AFN	6.6(B)
59	JS	42	MALE	1131503	03-07-2021	03-07-2021	RSA	RIGHT	MID SHAFT	32B3	DFN	4.91(B)
60	SS	37	MALE	1132846	06-07-2021	07-07-2021	DOMESTIC FALL	RIGHT	PROXIMAL SHAFT	32C3	AFN	11.17(C)
61	HS	35	MALE	1145013	30-07-2021	06-08-2021	RSA	RIGHT	PROXIMAL SHAFT	32C3	AFN	10.8(C)
62	NS	28	MALE	1154810	14-08-2021	15-08-2021	RSA	RIGHT	DISTAL SHAFT	32B2	DFN	10.91(C)
63	S	36	MALE	1154864	15-08-2021	16-08-2021	RSA	RIGHT	MID SHAFT	32B2	AFN	6.75(B)
64	IS	29	MALE	1156255	17-08-2021	17-08-2021	RSA	RIGHT	PROXIMAL SHAFT	32B3	AFN	7.06(B)
65	JS	37	MALE	1187354	07-10-2021	08-10-2021	RSA	RIGHT	MID SHAFT	32B2	AFN	8(C)
66	HD	47	MALE	1202126	04-11-2021	05-11-2021	RSA	RIGHT	MID SHAFT	32C2	AFN	1.84(A)
67	A	22	MALE	1203597	08-11-2021	08-11-2021	RSA	RIGHT	MID SHAFT	32B3	AFN	3.48(A)
68	PS	26	MALE	1219723	06-12-2021	07-12-2021	RSA	LEFT	MID SHAFT	32B2	AFN	2.42(A)
69	RR	22	MALE	1222762	13-12-2021	21-12-2021	RSA	RIGHT	MID SHAFT	32B2	AFN	3.49(A)
70	AS	55	MALE	217649	27-12-2021	29-12-2021	RSA	RIGHT	DISTAL SHAFT	32C3	DFN	9.24(C)
71	NS	26	MALE	1242730	21-01-2022	22-01-2022	RSA	LEFT	MID SHAFT	32B2	AFN	5.62(B)
72	RA	23	MALE	1025433	10-02-2022	12-02-2022	RSA	RIGHT	PROXIMAL SHAFT	32B3	AFN	12.26(C)
73	RK	26	FEMALE	1155023	15-08-2021	16-08-2021	RSA	RIGHT	MID SHAFT	32B2	AFN	7.21(B)
74	MK	40	MALE	1277022	26-03-2022	30-03-2022	RSA	LEFT	MID SHAFT	32B2	AFN	1.81(A)
75	G	20	MALE	1284225	08-04-2022	08-04-2022	RSA	LEFT	MID SHAFT	32B2	AFN	3.23(A)
76	MZK	32	MALE	1298495	05-05-2022	09-05-2022	RSA	RIGHT	PROXIMAL SHAFT	32B3	AFN	3.97(A)
77	HS	52	MALE	1298830	05-05-2022	06-05-2022	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	2.52(A)
78	JA	30	MALE	1301062	09-05-2022	09-05-2022	RSA	RIGHT	PROXIMAL SHAFT	32C3	AFN	17.85(C)
79	DS	23	MALE	1300316	09-05-2022	11-05-2022	RSA	RIGHT	MID SHAFT	32C3	AFN	15.2(C)
80	D	30	MALE	1308784	22-05-2022	25-05-2022	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	10.1(C)
81	VA	25	MALE	1313204	29-05-2022	29-05-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	5.6(B)
82	AK	35	MALE	1328805	24-05-2022	24-06-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	1.63(A)
83	GK	32	FEMALE	1330194	26-06-2022	27-06-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	1.24(A)
84	J	30	MALE	1334271	02-07-2022	27-06-2022	RSA	RIGHT	PROXIMAL SHAFT	32C2	AFN	18.27(C)
85	MS	22	MALE	1338613	10-07-2022	15-07-2022	RSA	LEFT	MID SHAFT	32B3	AFN	5.5(B)
86	AS	22	MALE	1344490	19-07-2022	22-07-2022	RSA	RIGHT	PROXIMAL SHAFT	32C3	AFN	15.4(C)
87	S	18	FEMALE	568591	19-07-2022	25-07-2022	RSA	LEFT	DISTAL SHAFT	32B2	DFN	1.16(A)
88	YB	22	MALE	1366915	26-08-2022	26-08-2022	RSA	LEFT	PROXIMAL SHAFT	32B2	AFN	1.79(A)
89	IK	20	MALE	1368414	28-08-2022	31-08-2022	RSA	RIGHT	MID SHAFT	32B3	AFN	5.79(B)
90	IK	20	MALE	1368413	28-08-2022	31-08-2022	RSA	LEFT	DISTAL SHAFT	32B2	DFN	5.16(B)
91	AM	21	MALE	1371555	02-09-2022	05-09-2022	RSA	LEFT	DISTAL SHAFT	32B3	AFN	3.13(A)
92	GS	18	MALE	1408308	03-11-2022	03-11-2022	RSA	LEFT	DISTAL SHAFT	32B2	DFN	1.52(A)
93	A	26	MALE	1409658	06-11-2022	07-11-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	2.47(A)
94	SS	34	MALE	1409659	06-11-2022	06-11-2022	RSA	RIGHT	MID SHAFT	32B3	AFN	2.91(A)
95	RA	25	MALE	1432562	15-12-2022	16-12-2022	RSA	RIGHT	MID SHAFT	32B2	AFN	1.54(A)
96	JS	25	MALE	1449833	23-01-2023	27-01-2023	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	1.32(A)
97	DSG	50	MALE	1453222	29-01-2023	29-01-2023	DF	RIGHT	PROXIMAL SHAFT	32C3	AFN	18(C)
98	HK	21	FEMALE	1467652	21-02-2023	22-02-2023	RSA	RIGHT	PROXIMAL SHAFT	32B2	AFN	1.73(A)
99	KS	33	MALE	1468906	23-02-2023	27-02-2023	RSA	RIGHT	DISTAL SHAFT	32B3	DFN	12.93(C)
100	GS	37	MALE	1473518	03-03-2023	03-03-2023	RSA	LEFT	MID SHAFT	32B2	AFN	1.28(A)
101	JS	45	MALE	1464614	16-02-2023	17-02-2023	RSA	LEFT	MID SHAFT	32B2	AFN	7.64(B)
102	JS	22	MALE	1499253	14-04-2023	15-04-2023	RSA	RIGHT	DISTAL SHAFT	32B2	AFN	8.09(C)
103	BK	55	FEMALE	1506343	26-04-2023	27-04-2023	RSA	RIGHT	DISTAL SHAFT	32B2	DFN	2.49(A)
104	SK	46	FEMALE	1518480	16-05-2023	17-05-2023	RSA	LEFT	DISTAL SHAFT	32B2	AFN	2.76(A)
105	T	18	FEMALE	1523072	24-05-2023	25-05-2023	FALL FROM HEIGHT	RIGHT	DISTAL SHAFT	32B2	DFN	1.99(A)
106	APS	25	MALE	1570405	12-08-2023	13-08-2023	RSA	RIGHT	MID SHAFT	32C3	AFN	14.7(C)

S.No	Third Fragment			Post Operative Management		Time of Fracture Union	
	Proximal Displacment(group)	Distal displacement(group)	Displacement using Lin method	Time of partial weight bearing(weeks)	time of full weight bearing(weeks)	Union(yes/no)	Union time(weeks)
54	4.1(P1)	1.5(D1)	SMALL GAP	6	14	YES	12
55	10.9(P2)	9.2(D1)	SMALL GAP	12	28	YES	24
56	13.9(P2)	12.3(D2)	SMALL GAP	12	20	YES	16
57	9.8(P1)	2(D1)	SMALL GAP	4	12	YES	12
58	9.2(P1)	4.6(D1)	SMALL GAP	4	12	YES	16
59	17.8(P2)	16(D2)	SMALL GAP	4	20	NO	NO
60	3.6(P1)	9.3(D1)	SMALL GAP	8	16	YES	16
61	21.8(P3)	11.3(D2)	LARGE GAP	12	20	YES	16
62	3.6(P1)	17.7(D2)	SMALL GAP	8	20	YES	16
63	9.7(P1)	6.5(D1)	SMALL GAP	28	36	YES	24
64	6.2(P1)	13.3(D2)	SMALL GAP	4	12	YES	16
65	47(P4)	59.5(D4)	LARGE GAP	8	24	YES	16
66	10.5(P2)	12.3(D2)	SMALL GAP	4	14	YES	16
67	7.8(P1)	7.1(D1)	SMALL GAP	6	12	YES	12
68	8.3(P1)	9.3(D1)	SMALL GAP	4	12	YES	16
69	9.2(P1)	10.3(D2)	SMALL GAP	4	14	YES	12
70	26.5(P3)	4(D1)	SMALL GAP	8	30	YES	16
71	9.9(P1)	1(D1)	SMALL GAP	10	16	YES	16
72	8.2(P1)	24(D3)	SMALL GAP	4	12	YES	12
73	11.4(P2)	1.6(D1)	SMALL GAP	6	24	YES	12
74	14.6(P1)	8(D1)	SMALL GAP	9	14	YES	16
75	7.2(P1)	6.6(D1)	SMALL GAP	8	16	YES	16
76	13.6(P1)	6(D1)	SMALL GAP	28	36	YES	12
77	10.9(P2)	5(D1)	SMALL GAP	16	36	YES	16
78	21.4(P3)	13.3(D2)	LARGE GAP	4	8	YES	12
79	10.1(P2)	17.6(D2)	SMALL GAP	8	18	YES	20
80	9.1(P1)	27.8(D3)	LARGE GAP	5	11	YES	24
81	40.2(P4)	45.7(D4)	LARGE GAP	4	12	YES	20
82	8(P1)	14.6(D2)	SMALL GAP	24	38	YES	24
83	12.6(P2)	13.1(D2)	SMALL GAP	8	16	YES	16
84	4(P1)	5.6(D1)	SMALL GAP	16	22	YES	16
85	11.7(P2)	12.7(D2)	SMALL GAP	16	22	YES	20
86	3.2(P1)	19.1(D2)	SMALL GAP	4	18	YES	12
87	5.9(P1)	12.9(D2)	SMALL GAP	4	12	YES	12
88	14.8(P2)	13.9(D2)	SMALL GAP	4	12	YES	12
89	13.9(P2)	9.5(D1)	SMALL GAP	12	20	YES	16
90	22(P3)	25.1(D3)	LARGE GAP	12	20	YES	20
91	11(P2)	11.1(D2)	SMALL GAP	6	24	YES	12
92	(P1)	6.2(D1)	SMALL GAP	8	4	YES	12
93	7.7(P1)	8.7(D1)	SMALL GAP	12	4	YES	12
94	6.1(P1)	3.1(D1)	SMALL GAP	6	14	YES	14
95	16.6(P2)	17(D2)	SMALL GAP	8	20	YES	20
96	11.7(P2)	12.2(D2)	SMALL GAP	10	24	YES	16
97	4.1(P1)	21.7(D3)	SMALL GAP	4	12	YES	20
98	3.6(P1)	6.7(D1)	SMALL GAP	4	12	YES	12
99	12.8(P2)	11.8(D2)	SMALL GAP	12	24	NO	NO
100	15.3(P2)	16.3(D2)	SMALL GAP	20	32	YES	16
101	7(P1)	10.1(D2)	SMALL GAP	4	20	YES	20
102	12.4(P2)	9.8(D1)	SMALL GAP	8	20	YES	24
103	3.6(P1)	11.3(D2)	SMALL GAP	8	16	YES	16
104	17.7(P2)	12.6(D2)	SMALL GAP	4	12	NO	NO
105	17.8(P2)	18.3(D2)	LARGE GAP	4	4	YES	20
106	16.9(P2)	17.6(D2)	LARGE GAP	8	16	YES	20

S.No	Final Hip ROM	Final Knee ROM	Pain (/10)	mHHS	OKS	Incidence of Complications					
			Final followup	Final followup	Final followup	Infection	Delayed union	Malunion	Non-union	Implant Failure	Resurgery
54	FLX 112, EXT 12	0-124	0	94	44	NO	NO	NO	NO	NO	NO
55	FLX 110, EXT 15	0-125	0	82	36	NO	NO	NO	NO	NO	NO
56	FLX 95, EXT 5	0-100	0	79	34	NO	NO	NO	NO	NO	NO
57	FLX 112, EXT 12	0-124	0	94	44	NO	NO	NO	NO	NO	NO
58	FLX 110, EXT 10	0-120	0	94	44	NO	NO	NO	NO	NO	NO
59	FLX 100, EXT 5	0-90	0	85	30	NO	NO	NO	YES	NO	YES(MAY,2022)
60	FLX 110, EXT 15	0-125	0	90	40	YES(SUTURE ABCESS)	NO	NO	NO	NO	YES(WOUND WASH)
61	FLX 108, EXT 10	0-110	0	94	44	NO	NO	NO	NO	NO	NO
62	FLX 110, EXT 15	0-130	0	92	40	NO	NO	NO	NO	NO	NO
63	FLX 110, EXT 10	0-125	0	89	40	NO	YES	NO	NO	NO	YES
64	FLX 105, EXT 15	0-128	0	84	40	NO	NO	NO	NO	NO	NO
65	FLX 90, EXT 5	0-70	1	80	28	NO	NO	NO	NO	NO	NO
66	FLX 90, EXT 5	0-110	1	79	30	NO	YES	NO	NO	NO	NO
67	FLX 110, EXT 12	0-128	0	88	40	NO	NO	NO	NO	NO	NO
68	FLX 112, EXT 10	0-124	0	96	44	NO	NO	NO	NO	NO	NO
69	FLX 114, EXT 12	0-126	0	92	44	YES(SUTURE ABCESS)	NO	NO	NO	NO	NO
70	FLX 90, EXT 5	0-90	0	79	29	NO	NO	NO	NO	NO	NO
71	FLX 100, EXT 5	0-124	0	88	46	NO	NO	NO	NO	NO	NO
72	FLX 110, EXT 15	0-120	0	82	36	NO	NO	NO	NO	NO	NO
73	FLX 110, EXT 12	0-125	0	90	40	NO	NO	NO	NO	NO	NO
74	FLX 110, EXT 15	0-130	0	86	44	NO	NO	NO	NO	NO	NO
75	FLX 110, EXT 15	0-130	0	86	44	NO	NO	NO	NO	NO	NO
76	FLX 90, EXT 10	0-90	0	84	38	NO	NO	NO	NO	YES	NO
77	FLX 110, EXT 15	0-100	0	94	44	NO	NO	NO	NO	YES	NO
78	FLX 110, EXT 15	0-130	0	94	42	NO	NO	NO	NO	NO	NO
79	FLX 110, EXT 15	0-130	0	92	44	NO	NO	NO	NO	NO	NO
80	FLX 100, EXT 15	0-130	0	92	42	NO	NO	NO	NO	NO	NO
81	FLX 110, EXT 15	0-130	0	94	46	NO	NO	NO	NO	NO	NO
82	FLX 112, EXT 12	0-130	0	94	45	NO	YES	NO	NO	NO	YES(9/22 DYNAMISATION)
83	FLX 110, EXT 15	0-130	0	92	44	NO	NO	NO	NO	NO	NO
84	FLX 110, EXT 15	0-130	0	94	44	NO	NO	NO	NO	NO	NO
85	FLX 90, EXT 5	0-90	0	88	38	NO	NO	NO	NO	NO	NO
86	FLX 100, EXT 15	0-110	0	94	44	NO	NO	NO	NO	NO	NO
87	FLX 110,EXT 20	0-130	0	94	44	NO	NO	NO	NO	NO	NO
88	FLX 110, EXT 15	0-130	0	94	46	NO	NO	NO	NO	NO	NO
89	FLX 108, EXT 10	0-70	0	90	32	YES(ABCESS SUTURE)	NO	NO	NO	NO	NO
90	FLX 110, EXT 10	0-110	0	92	44	NO	NO	NO	NO	NO	NO
91	FLX 110,EXT 15	0-135	0	94	44	NO	NO	NO	NO	NO	NO
92	FLX 110,EXT 15	0-105	0	94	40	NO	NO	NO	NO	NO	NO
93	FLX 100,EXT 10	0-110	0	88	36	NO	NO	NO	NO	NO	NO
94	FLX 90, EXT 10	0-90	0	86	38	NO	NO	NO	NO	NO	NO
95	FLX 110, EXT 15	0-125	0	92	45	NO	YES	NO	NO	NO	YES(DYNAMISATION)
96	FLX 110, EXT 10	0-124	0	84	40	NO	NO	NO	NO	NO	NO
97	FLX 90, EXT 2	0-86	0	80	35	NO	NO	NO	NO	NO	NO
98	FLX 110, EXT 15	0-130	0	95	45	NO	NO	NO	NO	NO	NO
99	FLX 80, EXT 5	0-90	2	82	39	NO	NO	NO	YES	NO	YES(JUN 23)
100	FLX 90, EXT 5	0-90	0	84	37	NO	NO	NO	NO	NO	NO
101	FLX 120,EXT 10	0-125	0	95	44	NO	NO	NO	NO	NO	NO
102	FLX 115, EXT 20	0-135	0	94	44	NO	NO	NO	NO	NO	NO
103	FLX 108, EXT 10	0-110	0	92	42	NO	NO	NO	NO	NO	NO
104	FLX 115, EXT 20	0-125	0	86	42	NO	NO	NO	NO	NO	NO
105	FLX 110,EXT 15	0-135	0	95	44	NO	NO	NO	NO	NO	NO
106	FLX 110, EXT 10	0-120	0	90	44	NO	NO	NO	NO	NO	NO

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Subject:: Approval of Plan of Thesis.

This is to inform you that the Faculty of Medical Sciences in its meeting held on 25.09.2023 has approved the plan of thesis of **Vikramjeet Singh**, a student of your college for **MS Orthopaedics** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Effect of the third fragment on union of femoral shaft fractures managed with intramedullary nailing .

Supervisor	**Co-Supervisor:-**	**Co-Supervisor:-**
Dr. Deepak Jain	Dr. Rajnish Garg	Dr. Pankaj Mahindra
Professor	Prof. & Head	Professor
Dept. of Orthopaedics,	Dept. of Orthopaedics	Dept. of Orthopaedics

The student may submit the thesis in triplicate alongwith the plan in triplicate also, to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She may be directed to attach a photocopy of this letter with the forwarding letter while submitting thesis in the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic, if any.

Controller of Examinations

Note :

1. *If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.*

EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SURGERY

IN

ORTHOPAEDICS

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

JUNE, 2022

DR VIKRAMJEET SINGH

DEPARTMENT OF ORTHOPAEDICS

DAYANAND MEDICAL COLLEGE AND HOSPITAL, LUDHIANA

ABSTRACT OF PLAN OF THESIS

Title	EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING
For the degree of	MS ORTHOPAEDICS
Name of the candidate	DR VIKRAMJEET SINGH
Supervisor	DR DEEPAK JAIN, PROFESSOR, DEPARTMENT OF ORTHOPAEDICS, DMCH, LUDHIANA
Co-supervisor	1. DR RAJNISH GARG, PROFESSOR & HEAD, DEPARTMENT OF ORTHOPAEDICS, DMCH, LUDHIANA 2. DR PANKAJ MAHINDRA, PROFESSOR, DEPARTMENT OF ORTHOPAEDICS
Institution	DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA
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Introduction: Femoral fractures are very common nowadays. These are either due to high energy trauma like RSA, sports injuries, fall from height or may be due to trivial trauma in case of elderly osteoporotic bones. Closed reduction and internal fixation along with reaming of bone is the most widely used technique for fixation of these femoral shaft fractures as they are associated with high rate of fracture union and decreased association with non-union, delayed union, infection rates and better functional outcomes. The femoral shaft fractures can sometimes present with third fragment which usually shows high non-union rates. Standard open reduction may not be useful in these cases as it may cause increased chances of infection and injury to vascular bed of fracture site. The literature is not clear with regards to whether to leave these fragments as such or bring these close to the fernur shaft or fix them with encirclage. Through this study, we aim to assess the parameters which determine union of third fragment.

Aim of Study: To study the effect of third fragment in terms of its size, location/displacement and angulation on fracture union.

Materials & methods: The patients operated withclosed reduction and internal fixation with intramedullary nailing of shaft femur fracture with third fragment in Dayanand Medical College & Hospital, Ludhiana will be initiated for the study after fulfilling the inclusion and exclusion criteria and evaluated in the post-operative period on the basis of effect if third fragment on fracture union, as well as evaluated using the Harris Hip Score (HHS) and oxford knee score in the post-operative period at monthly intervals. The effect of third fragment on fracture union managed with intramedullary nailing will be studied.

Clinical Significance: The present study is meant to evaluate the effect of third fragment of fracture shaft femur managed with intramedullary nailing prospectively and retrospectively based on parameters used and to reflect the functional outcome, like range of motion of knee, hip etc

Keywords: Non union, Third Fragment, Fracture shaft femur, Intramedullary nailing, Functional outcome.

(Signature) Candidate | (Signature) Co-supervisor | (Signature) Co-supervisor | (Signature) Supervisor | (Signature) Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING"** exist in the Department of Orthopaedics at DMC&H, Ludhiana and will be provided to be candidate of will be provided to the candidate. We will see that the data being included in the thesis are genuine and is collected by the candidate himself under our supervision and guidance.

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APPROVAL PROFORMA

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Topic of Thesis	EFFECT OF THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING.
Likely date of appearing in PG examination	MAY 2024
Date of enrollment	
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Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
Dr. Harpreet Kaur (Professor & Head, Pathology)	Mr. R K Sharma (Legal Expert)
Dr. Jaspal Singh (Professor & Head, Surgery)	Dr. Ramit Mahajan (Associate Professor, Gastroenterology)
Dr. Dinesh Gupta (Professor & Head, Medicine)	Dr. Anu Sharma (Professor, Anatomy)
Dr. Sandeep Kaushal (Dean Academics & Professor & Head, Pharmacology)	Dr. Sandeep Kaushal (Dean Academics & Professor & Head, Pharmacology)
Dr. Gurpreet S Wander (Vice Principal)	Dr. Gurpreet S Wander (Vice Principal & Professor & Head, Cardiology)
	Dr. Gagandeep Singh (Secretary, Ethics Committee Professor & Head, Neurology)

Approved: Yes / No

Dr. Sandeep Puri
Chairperson
Research Committee
Chairperson
Research Committee

Approved: Yes / No

Prof. Arvind Malhotra
Chairperson
Ethics Committee
Chairperson
Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES,

FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	DR VIKRAMJEET SINGH STREET POTHI MALA, VPO & TEHSIL GURUHARSAHAI, FEROZEPUR, PUNJAB
2	NAME OF THE INSTITUTE	DAYANAND MEDICAL COLLEGE AND HOSPITAL
3	COURSE OF STUDY AND SUBJECT	MS ORTHOPAEDICS
4	DATE OF ADMISSION OF COURSE	07 MARCH, 2022
5	TITLE OF THE TOPIC	EFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

Closed reduction and internal fixation of shaft femur is indicated for a number of traumatic as well as incapacitating conditions. Operations on the femur fracture are among the most often performed surgical procedures performed in orthopaedics. Closed approaches to femur fracture are required for adequate fixation. The principles of surgical intervention include a thorough knowledge of anatomy of the region and its variations[(5)], proper patient positioning and adequate reduction. Dissections through natural cleavage planes help to minimize bleeding and disruption of important functional structures.

Femoral shaft fractures were not uncommon in adults who sustain high-energy trauma. Intramedullary nailing of the femur is suggested because of its satisfactory union rate under stable biomechanical circumstances. Now a days, closed reduction and internal fixation with an interlocking nail for fracture of the femoral shaft is generally accepted as a standard treatment and it has been extended to nearly all shaft fractures from the proximal to the distal femur. femoral shaft fracture are demonstrated in 10.5– 34% of all femoral fractures, and a large butterfly fragment may result in technical difficulties in anatomical restoration such that the residual gap usually persisted after closed reduction.

Whether a residual gap after closed reduction results in a higher risk of nonunion in such a group remains unclear. Furthermore, the butterfly fragment occasionally represents a reversed morphology such that the endosteum turns inside out. It is possible that the reversed fragment may further affect bone healing because of vascular bed compromise and difficult callus bridging over fragment gaps. Hence, it is worthy of investigation Injury

The available literature is not clear with regards to whether to leave these fragments as such or bring these close to the femur shaft or fix them with cerclage. My study aim to determine theparameterswhether the

displacement and morphology of a fragment in femur fracture Orthopaedic Trauma Association/32- B/32-C (AO/OTA/32-B/32-C) classification affect the outcomes following closed reduction and internal fixation with an interlocking nail which determine union of third fragment.

6.2 REVIEW OF LITERATURE

Shih-Jie Lin et al.(2013) conducted a a retrospective study to investigate Effect of fragmentary displacement and morphology in the treatment of comminuted femoral shaft fractures with an intramedullary nail. They small and large gap groups at 12 months postoperatively was 75.9% and 21.1%, respectively . The mean union time of those union cases in these two groups was 7.8 and 13.0 months, respectively. The union rate of the non-reversed and reversed groups at 12 months postoperatively was 30% and 11.1%, respectively.The mean RUSF at 12 months in the non-reversed and reversed groups was 8.8 and 8.3, respectively. However, they found that patients presenting a reversed fragment had an increased risk of more than one re-operation. They concluded that a fragmentary displacement of >1 cm in AO/OTA-type 32-B/32-C femoral shaft fracture after nailing affected bone healing. Among the large-gap group patients, an unreduced reverse fragment presented a negative prognostic factor for re-operation

Vicenti et al. (2018) conducted a retrospective study to investigate the impact of the radiological features of the third fragment on the outcome of femoral shaft fractures type 32-B managed with intramedullary nailing. They concluded that third fragment size and mean third fragment displacement effect fracture healing time most, according to regression analysis. Third fragment size (cutoff 40 mm) is the leading parameter for fracture healing within six months. Third fragment displacement (12mm cutoff); fracture affects slowed rather than prevented healing.[13]

Hamahashi et al. (2019) retrospectively studied the clinical results of intramedullary nailing of femoral shaft fractures with third fragments and risk factors for delayed union. displacement of the third fragment was found to be multiple logistic regression as a risk factor for delayed union.[14]

Layon et al.(2020) evaluated the union rates of femoral shaft fractures with flipped intercalary segments. Radiographic femur union

scores was used to evaluate union rates (RUSF). Though rare, femoral shaft fractures with reversed intercalary segments create surgical complications. Previous research had linked large intercalary segments to higher non-union rates, however their study contradicted that. Flipped intercalary segments may not require different surgical treatment than normal femoral shaft fractures.[15]

Jamoh et al.(2021) undertook a retrospective analysis in order to determine the union rate of fractured femur shafts with third pieces following closed intramedullary nailing. AO/ASIF categorization was done. Intramedullary closed nails were used to treat fractures and were followed up in OPD till fracture united. The findings indicated that the average duration for union of a shaft femur fracture were 30 weeks, which is longer than average. They came to the conclusion that the union rate of the bone is proportional to the displacement of third fragments and is independent of fragment size when treating shaft femur fractures with third fragments using the closed intramedullary nail technique.[16]

Tsai et al(2022) compared intramedullary (IM) nailing with or without fixation of the third piece. Two groups were treated: closed reduction without affecting the third fragment and open reduction with fixation. they concluded that Fixing the third fragment in wedge-shaped femoral shaft fractures slows healing and reduces union rates. When treating a femoral fracture with a third fragment, a bigger nail size and closed fixation are advised. Fragment fixation improves fracture reduction. Disruption of the vasculature and adjacent structures can cause nonunion.[17]

Yang et al.(2022) investigated the impact of the third fragment's degree of displacement on the degree of fracture healing following intramedullary nailing. They came to the conclusion that whereas fractures with large displacement should be minimised to as close to the diaphyseal bone defect as possible to prevent nonunion, the third fragment with less displacement required no intervention. The incidence of nonunion should

be reduced by treating the third fragments with closed reduction whenever it is possible to obtain a displacement within the range of grade I.[18]

6.3 AIMS AND OBJECTIVES OF THE STUDY

To determine the effect of third fragment on union of femoral shaft fractures managed with intramedullary nailing of femur

The secondary objective is:

- To evaluate the clinical and functional outcomes of fracture shaft femur with third fragment managed by intramedullary nailing.
- To study reoperation rates in fracture shaft femur with third fragment managed by intramedullary nailing.

7. MATERIALS AND METHODS

This study will be conducted in the Department of Orthopaedics, Dayanand Medical College and Hospital, Ludhiana retrospectively and prospectively to evaluate the effect of third fragment on the union of femoral shaft fractures managed with intramedullary nailing from March 2022- December 2023 prospectively and from January 2021 – feburary 2022 retrospectively. The patients aged 18-60 years old will be included in this study after fulfilling the required inclusion criteria. A detailed history will be taken from all the patients having femur shaft fractures. Retrospective and prospective study of fracture shaft femur with intramedullary nailing will be done. Radiographical and clinical union will be assessed and effect of third fragment in union will be evaluated.A femoral shaft fracture will be defined as a fracture in the area beginning 5 cm distal to the lesser trochanter and ranging to 5 cm proximal to the adductor tubercle. Patients with AO/OTA type 32B/32C will be included. Patients will be followed up till fracture union or 6 months whichever is later.

7.1 SOURCE OF DATA

It will be a prospective study for cases from 1st January 2021 through 31st Decmeber 2023 for all the patients admitted in Dayanand Medical College and Hospital under department of orthopaedics diagnosed as closed fracture shaft of femur and selected for after considering the inclusion and exclusion criteria which is as follows:

7.2 METHOD OF COLLECTION OF DATA

Study setting:

Collection of data as per the standard performa with consent obtained from patients admitted in the department of Orthopaedics, Dayanand Medical College & Hospital, Ludhiana from January 2021 to December 2023.

INCLUSION CRITERION

- Patients in 18-60 years of age group

- Closed Femur shaft fracture type 32-B and 32C (AO/OTA) surgically managed with intramedullary nailing (Retrograde /anterograde)
- Patients who consented for the surgery.
- Minimum clinical and radiological follow-up of atleast 6 months

EXCLUSION CRITERION

- Type 32-A fractures according to AO/OTA classification system
- Surgical management with open reduction and internal fixation
- Concomitant ipsilateral femur neck fracture fracture, periprosthetic fracture or open fractures.
- Duration of fracture >3 weeks
- Patients with pathological fractures or previous surgeries of involved femur.

Methods

Surgical technique

- The average time interval between injury and operation will be noted. Reamed nails will be used as intramedullary nails in all the surgeries using standard techniques. Nailing will be performed in all the cases after closed reduction.

Post-operative

Method of assessment

Assessment will be done using criteria used by J.R.LEE et al and Shih-jie Lin et al

J.R.Lee et al- used two parameters (1) fragment length

(2) fragment displacement

Fragment length:-

- The size of each fracture fragment will be determined by measuring the length of its long axis using plain radiographic images.

- Fragments will be divided into the following groups according to axis length:
    - group A (0–3.9 cm)
    - group B (4–7.9 cm)
    - group C (8 or >8 cm)
- **Fragment displacement:-**
- This will be measured by determining the perpendicular distance of the proximal (P) or distal (D) end of the fracture to the nearest cortex of the femoral shaft.
- The longest perpendicular distances between the P tips and the D tips of the fragments

Fractures will be then divided into the following groups:

- group P1 or D1 (between 0–9 mm)
- group P2 or D2, (between 10–19 mm)
- group P3 or D3 (between 20–29 mm)
- group P4 or D4 (30 mm or more).

Shih jie lin:- used one parameter :- Displacement of third fragment.

The enrolled patients with femoral shaft fractures will be subdivided into

- Small gap(≤10 mm)
- Large gap(>10 mm)

Numerical value for the displacement of a third fragment will be calculated as

Dprox + Ddist - Bd,

Where Dprox/Ddist is the largest perpendicular distance of the proximal/distal end of fragments to the midline of the shaft measured from antero-posterior and lateral radiographs and Bd is the diameter of the shaft at the fracture site on the same radiographs.

Postoperative Management:

- Range Of Motion will be initiated post operatively after 24 hours of surgery. weight bearing walking will be initiated according to

fracture geometry and fixation construction. After that callus formation will be observed upon completion of the non-weight-bearing, partial weight bearing training will be conducted.

- Follow up on monthly basis for clinical and radiological sign of union. Weight bearing walking will be decided according to progress of bone union.
- Bone union will be defined as bone continuity in 3 or more of the 4 cortical bone surfaces. Radiographic bone union rates and times according to fracture size and degree of fragment displacement will be investigated

STATISTICAL ANALYSIS

Data will be described in terms of range; mean ±standard deviation (± SD), median, frequencies (number of cases) and relative frequencies (percentages) as appropriate. To determine whether the data is normally distributed Comparison of quantitative variables between the study groups will be done using Student t-test and Mann Whitney U test for independent samples for parametric and non-parametric data respectively. For comparing categorical data, Chi square ($\chi 2$) test will be performed and fisher exact test was used when the expected frequency is less than 5. A probability value (p value) less than 0.05 will be considered statistically significant. All statistical calculations will be done using (Statistical Package for the Social Science) SPSS 21version (SPSS Inc., Chicago, IL, USA) statistical program for Microsoft Windows

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

No special investigation or intervention for the purpose of this study only, will be conducted.

7.4 HAS ETHICAL CLEARENCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

(Applied for)

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PROFORMA

Sr. No.
Name Age
Sex MRD

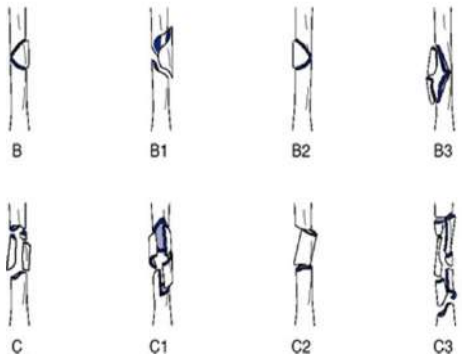
D.O.A	D.O.S	D.O.D

Clinical history:

- Mode of injury: Domestic fall/ Road Side Accident / Other

Fracture characteristics:

- Side affected: Left / Right
- Site of fracture: Proximal shaft / mid shaft / Distal shaft
- AO/OTA Fracture classification:32B / 32C



Third Fragment:

- Number of fragments:
- Fragment size (in cm):
- Proximal displacement (in mm) :
- Distal displacement (in mm):
- Angulation (in degree):
- Displacement using Lin method [$\mathbf{D^{prox} + D^{dist} - B^{d}}$] (in mm):

Operative details:-

- Duration between injury and surgery (number of days):-
- Anaesthesia: Spinal Anaesthesia / Combined Spinal epidural (CSE) / General Anaesthesia / Regional Anaesthesia
- Proximal locking (number of screws): One / Two/ Three
- Distal locking (number of screws): One / Two / Three

Signature of candidate Signature of Supervisor

POST OPERATIVE MANAGEMENT:

- Time of partial weight bearing (in days):
- Time of full weight bearing (in days) :

  1. With support:
  2. Without support:

TIME OF FRACTURE UNION

- **Union:** Yes / No
- **Union time:**

	1 Month	**2 Months**	**3 Months**	**4 Months**	**5 Months**	**6 Months**
Pain (VAS Score)						
Hip ROM (Modified Harris Hip Score, mHHS)						
Knee ROM (Oxford knee score)						
X ray – callus formation/ Union						
Re-fracture / implantfailure						

Incidence of complications

- Infection:
  - Date of incidence
  - Time lag between surgery and incidence of complication
- Delayed union
  - Date of incidence
  - Time lag between surgery and incidence of complication:

Signature of candidate Signature of Supervisor

- Malunion
    - Date of incidence
    - Time lag between surgery and incidence of complication:

- Non-union
    - Date of incidence
    - Time lag between surgery and incidence of complication:

- Implant failure
    - Date of incidence
    - Time lag between surgery and incidence of complication:
- Resurgery
    - Date of incidence
    - Time lag between surgery and incidence of complication:

Signature of candidate Signature of Supervisor

INFORMED PATIENT CONSENT

Date: _____

I……..D/o,W/o,S/o…… ……. ……am willing to participate in the study "**EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING**" The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

…… ……

Signature of the Witness Signature of the patient

Name:

Signature of Candidate **Signature of Supervisor**

मरीज अनुमति फार्म

तिथि _____

मैं _____ पत्नी/पुत्र/पुत्री _____

निवासी _____ इस शोधकार्य "**EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING**" में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____ _____

गवाह के हस्ताक्षर रोगी के हस्ताक्षर/अंगूठे का निशान

नाम: नाम:

_____

अन्वेषक केहस्ताक्षर

_____

विद्यार्थी के हस्ताक्षर

<u>ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ</u>

ਮਿਤੀ_____

ਮੈ_____ ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____ ਵਾਸੀ _____ “**EFFECT OF THE THIRD FRAGMENT ON UNION OF FEMORAL SHAFT FRACTURES MANAGED WITH INTRAMEDULLARY NAILING**” ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾਮਨੇਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ–ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

_____ _____

ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____ ਮਿਤੀ_____

ਪਤਾ _____ ਪਤਾ _____

_____

ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

_____

ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ